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CH2 F116
U1S 1698 1700 1706 1707 E1D

(56) Documents cited
GB 1393577 GB 1265734 EP A1 0163117
US 4542613

(58) Field of search
E1D
Selected US specifications from IPC sub-classes E04C E04B

(54) Foam panels and blocks of hollow profiles, the manufacture thereof, and the use thereof as insulating and/or drainage panels

(57) Foam panels and blocks are provided which are produced by welding and/or adhering foam tubes (1) to one another. The foam panels are used particularly as insulating and/or drainage panels, and the foam blocks are used for the production of super-lightweight panels the cavities of which are optionally filled with gypsum, cement, or other material. Composite structures made therefrom exhibit excellent sound-absorbent properties.

Moreover, the invention provides a process and an apparatus for welding foamed synthetic resin tubes to one another and/or to other foam materials. The synthetic resin surfaces to be welded together are guided by way of a spacer means at a distance past an electrically heated heat source to form a heating channel where the surfaces are melted and pressed together thereafter. The process and the apparatus are suited especially well for welding foams of non-crosslinked low-density polyethylenes.

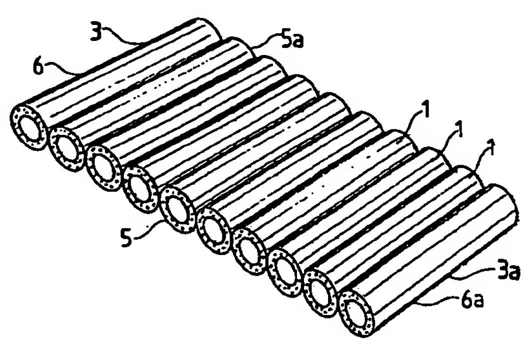

Fig. 1

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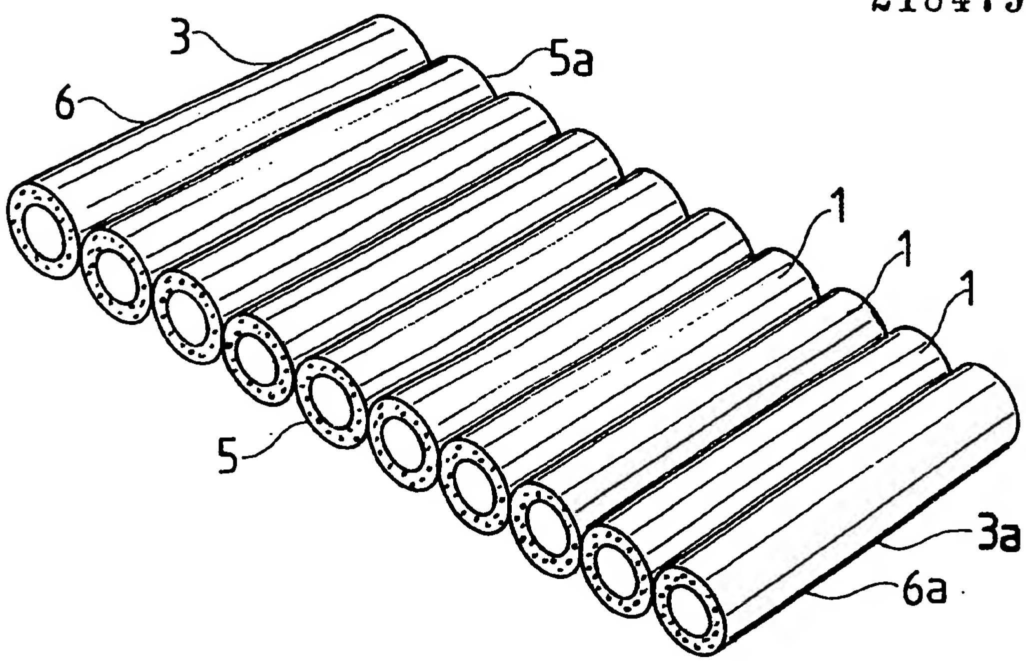

Fig. 1

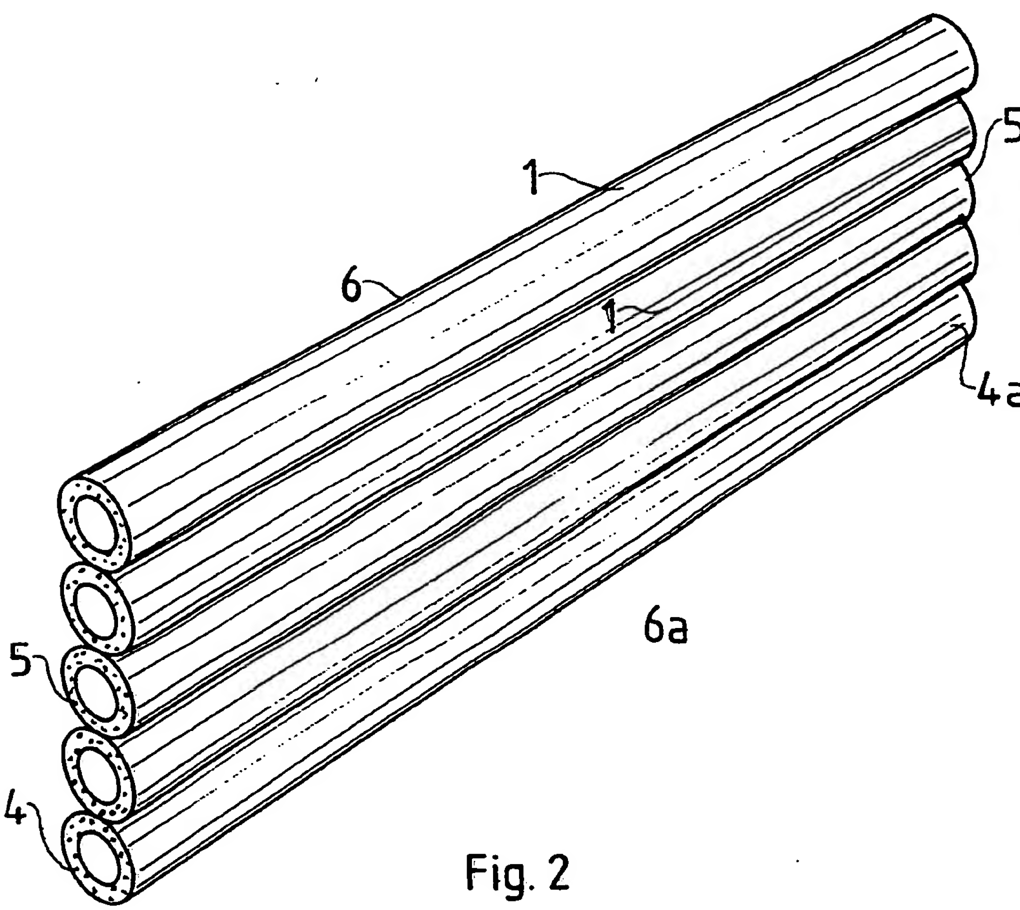

Fig. 2

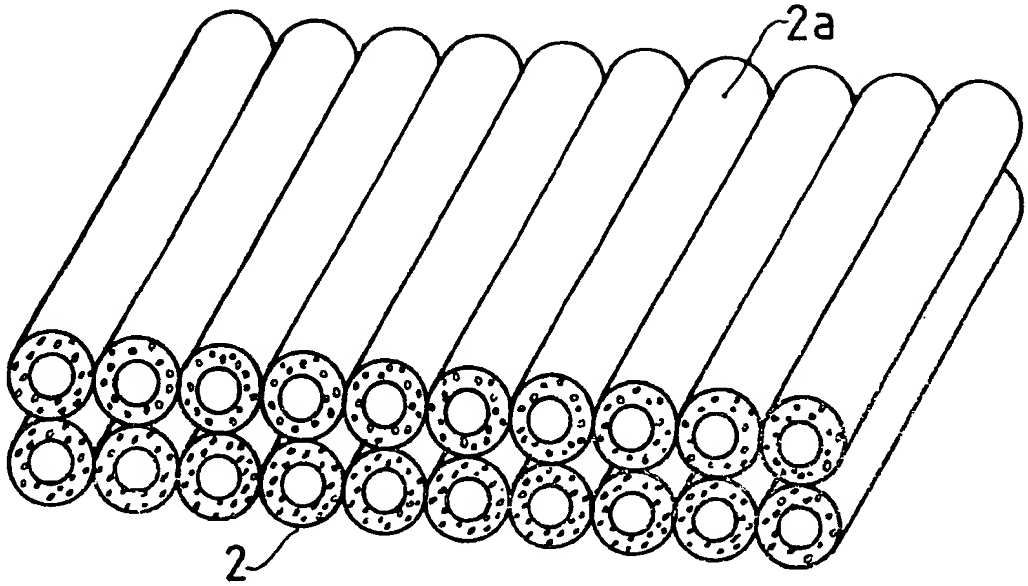

FIG. 3

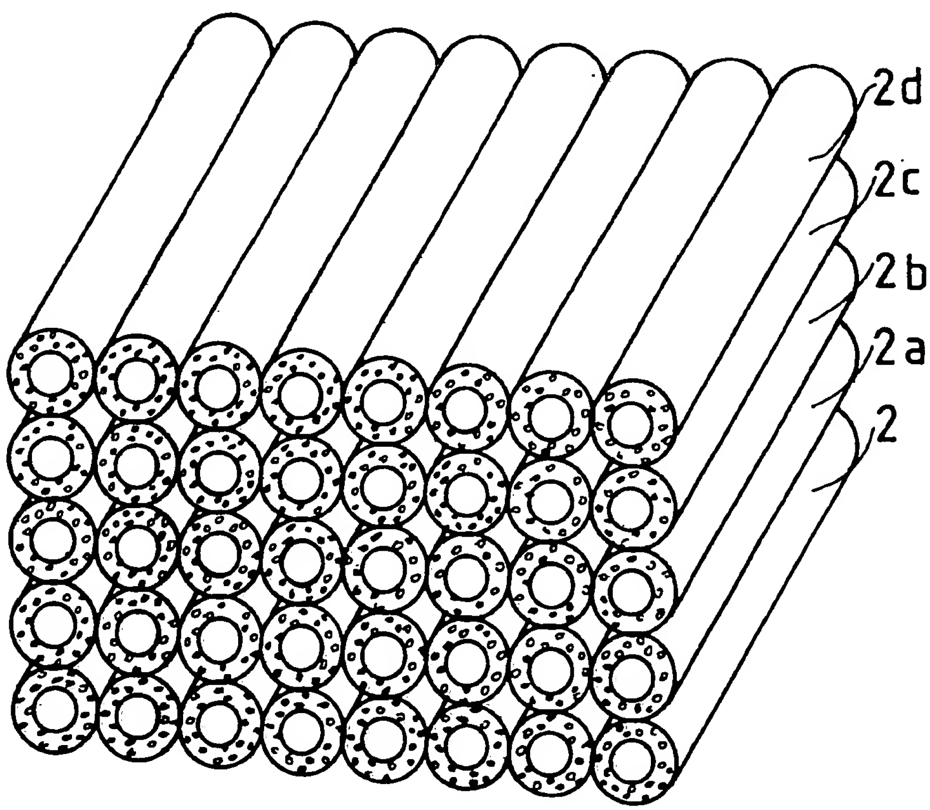

FIG. 4

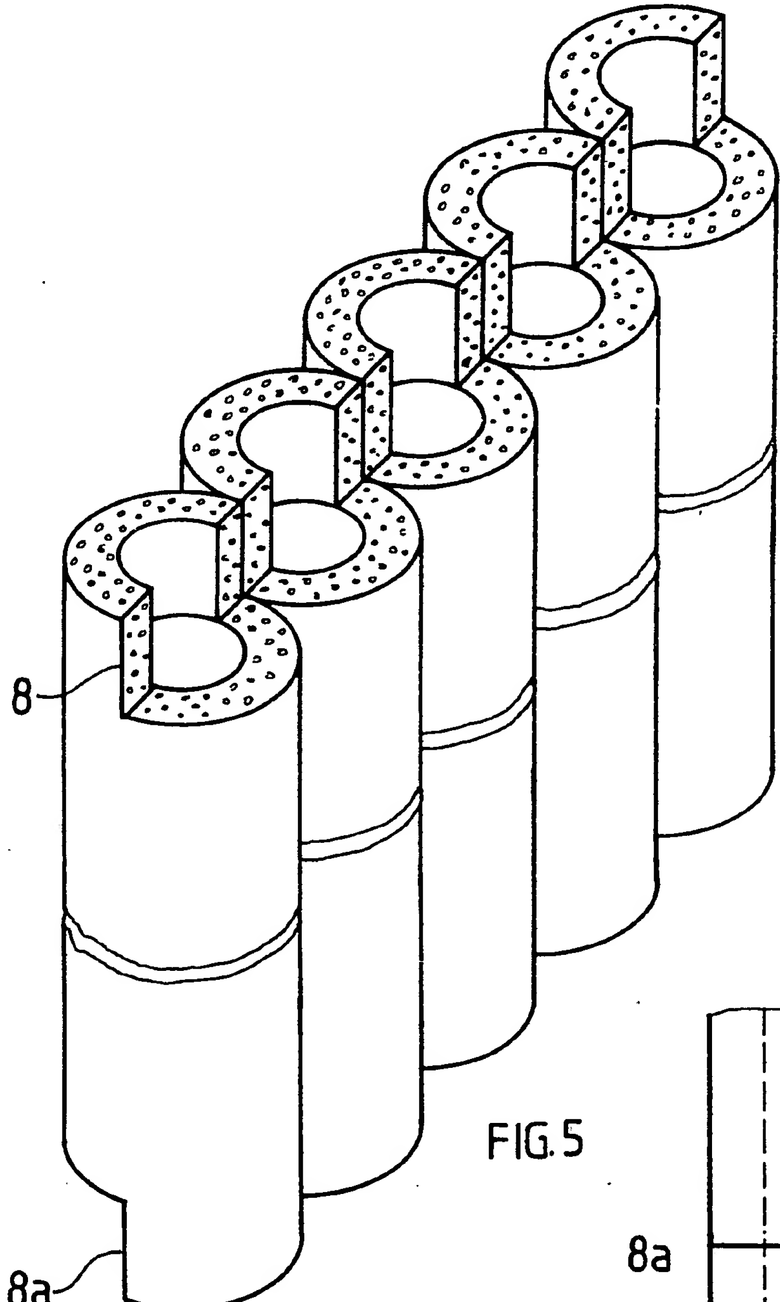

FIG.5

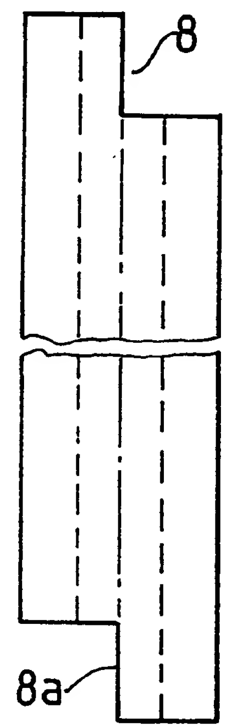

FIG.5a

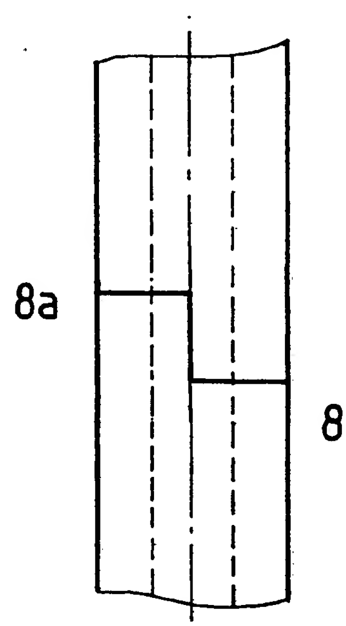

FIG.5b

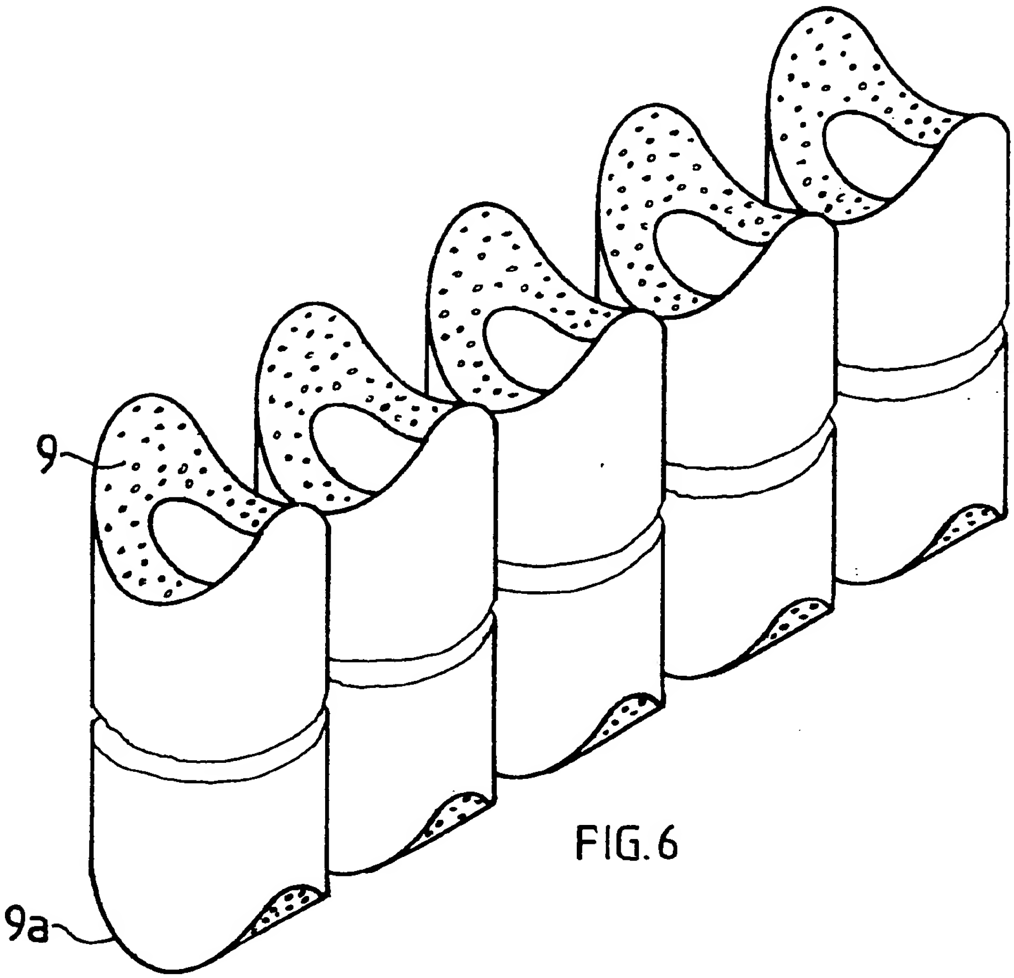

FIG.6

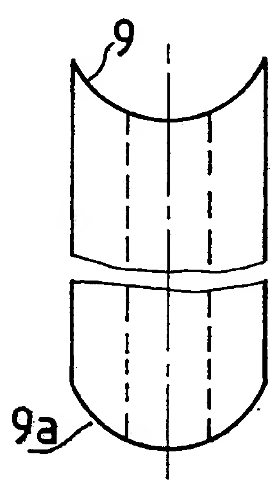

FIG.6a

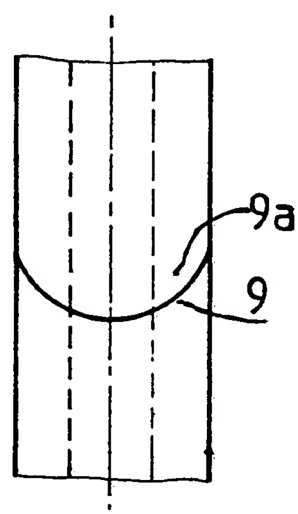

FIG.6b

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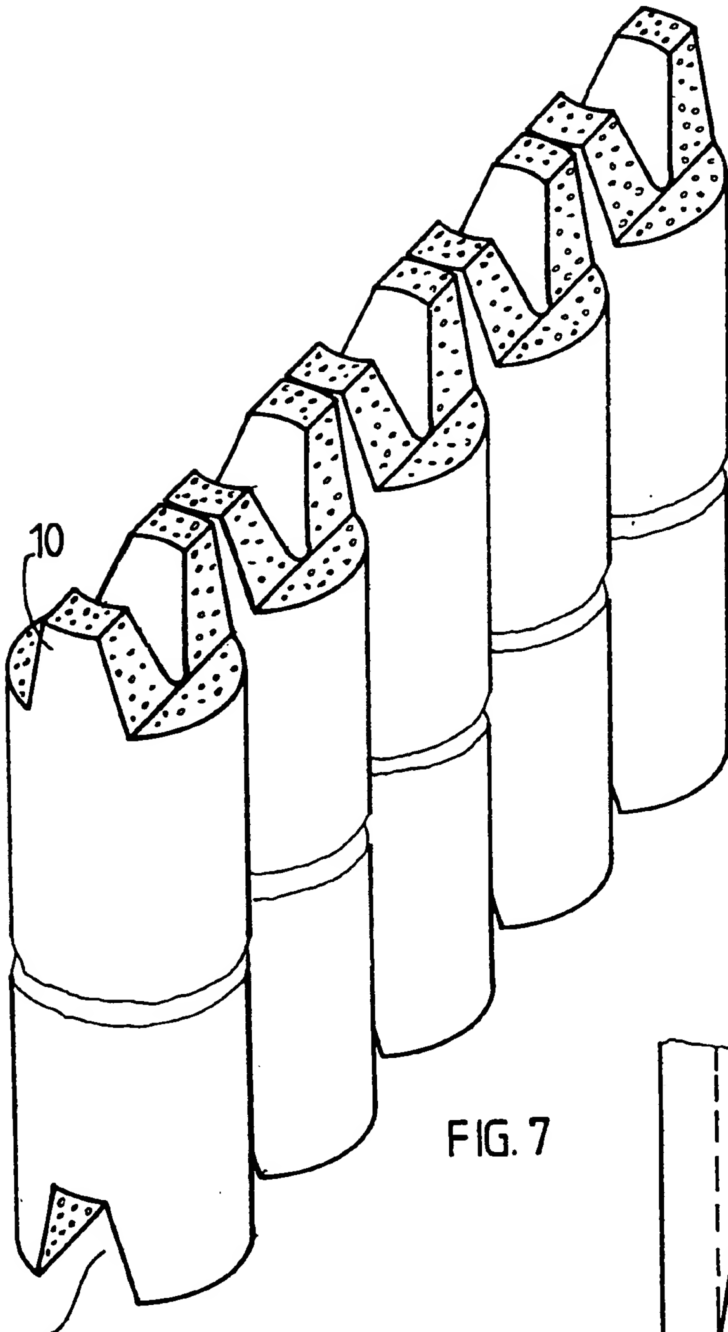
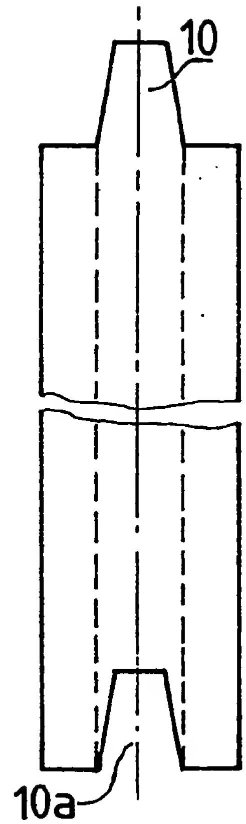


FIG. 7



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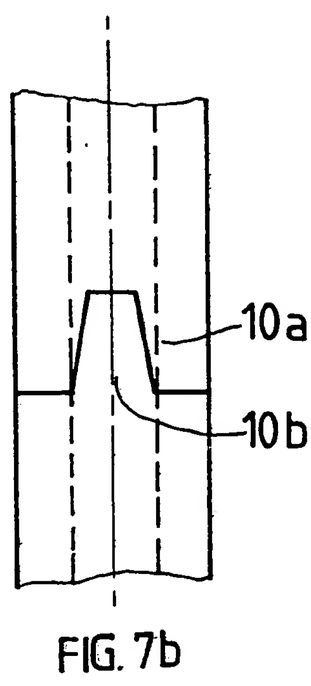

FIG. 7b

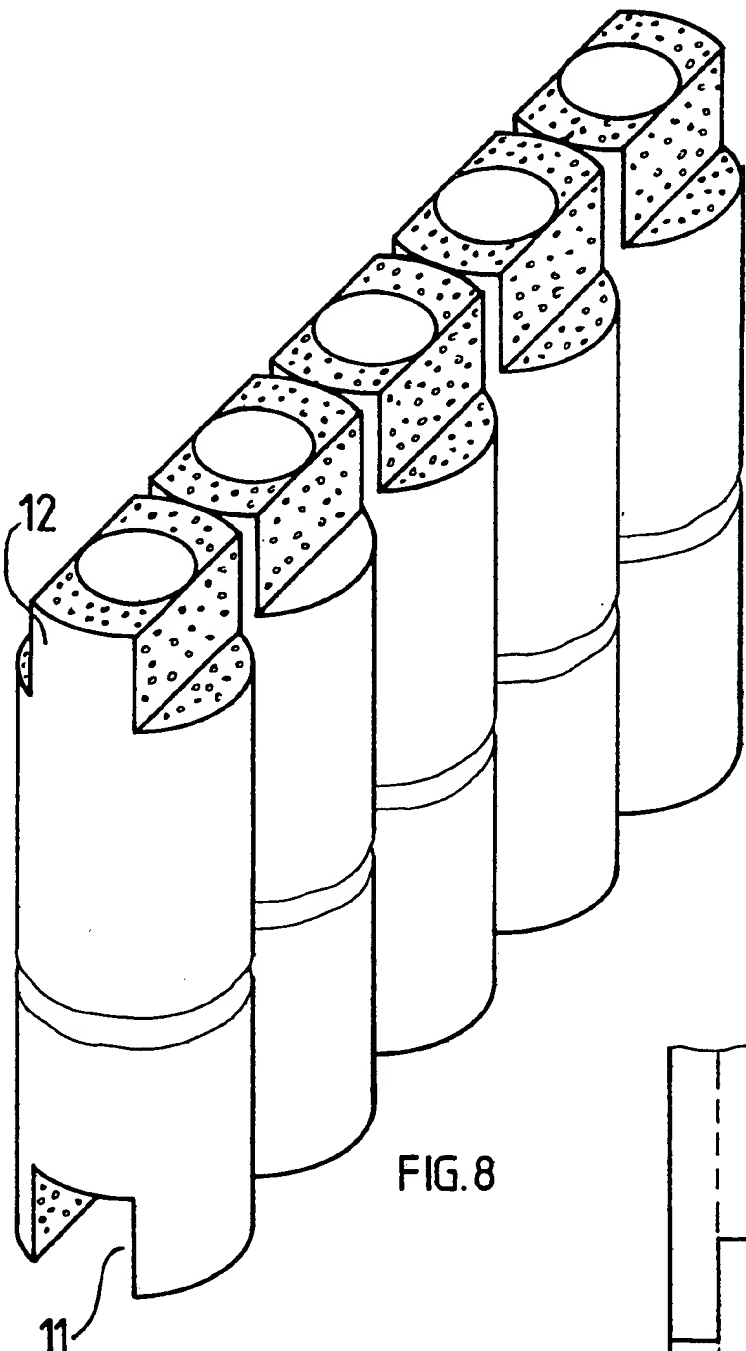

FIG. 8

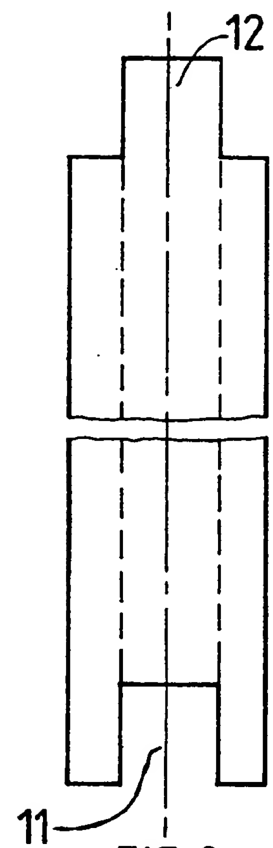

FIG. 8a

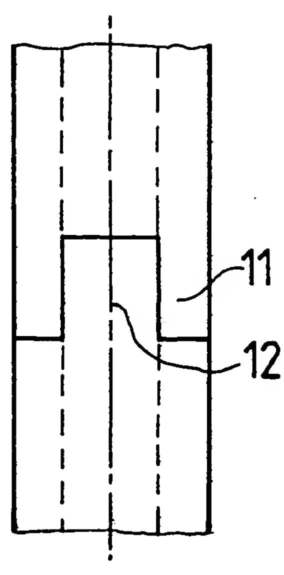

FIG. 8b

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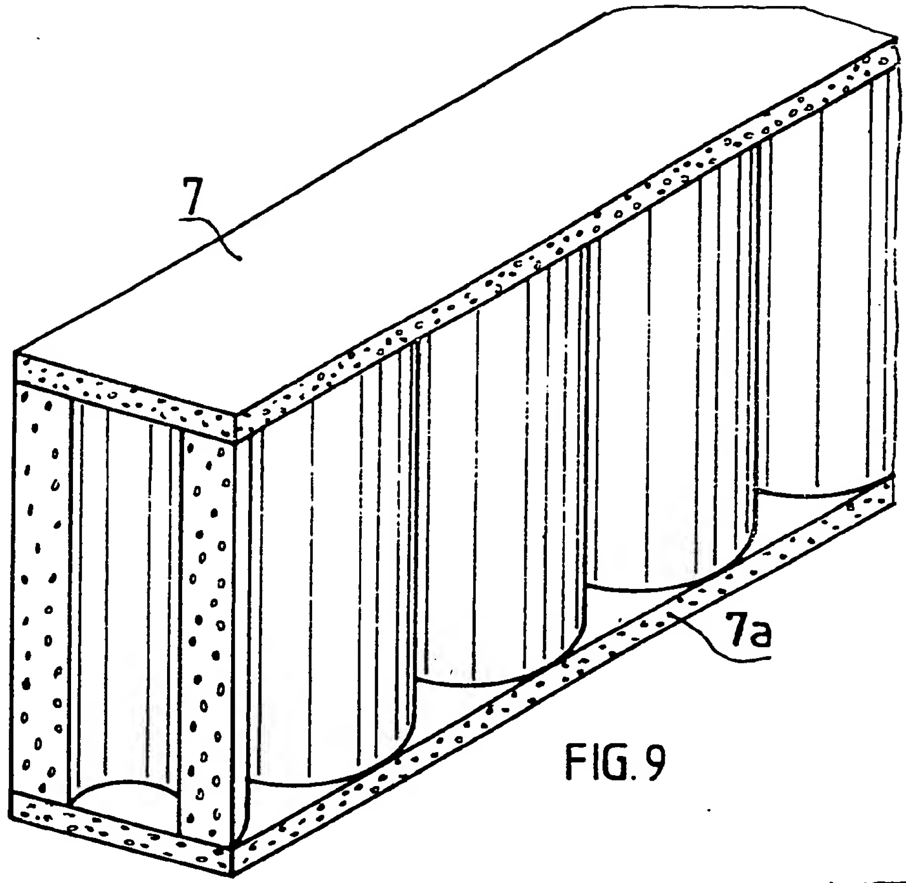


FIG.9

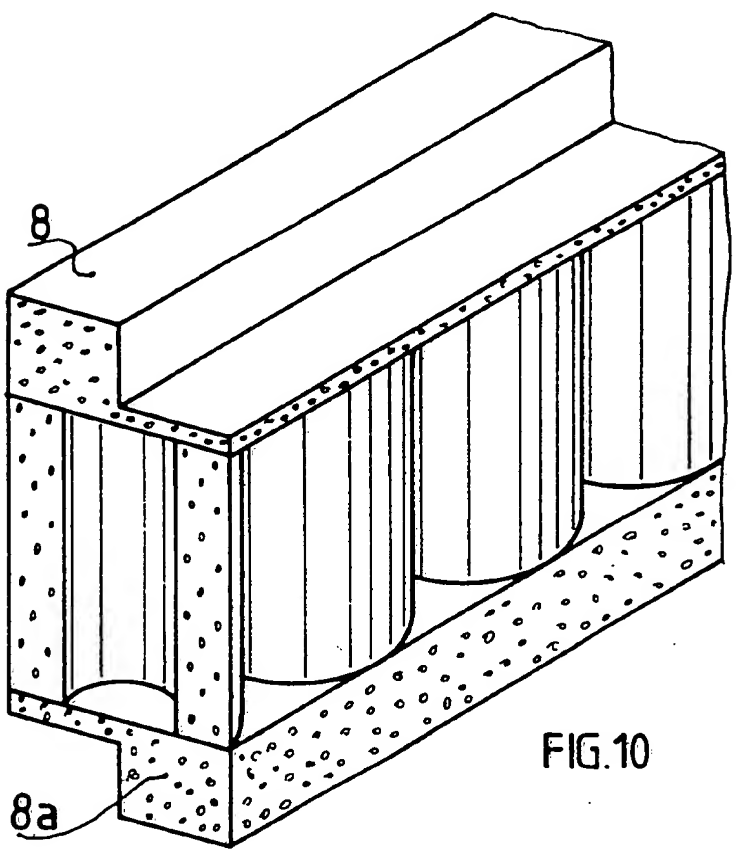


FIG.10

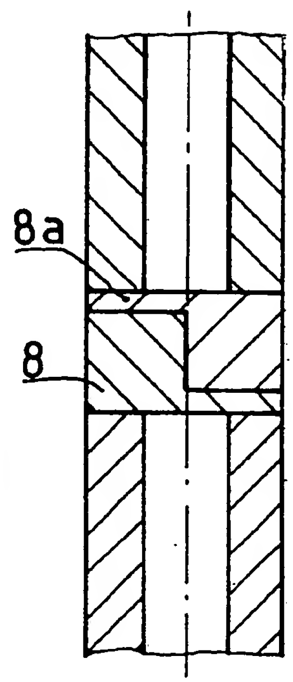


FIG.10a

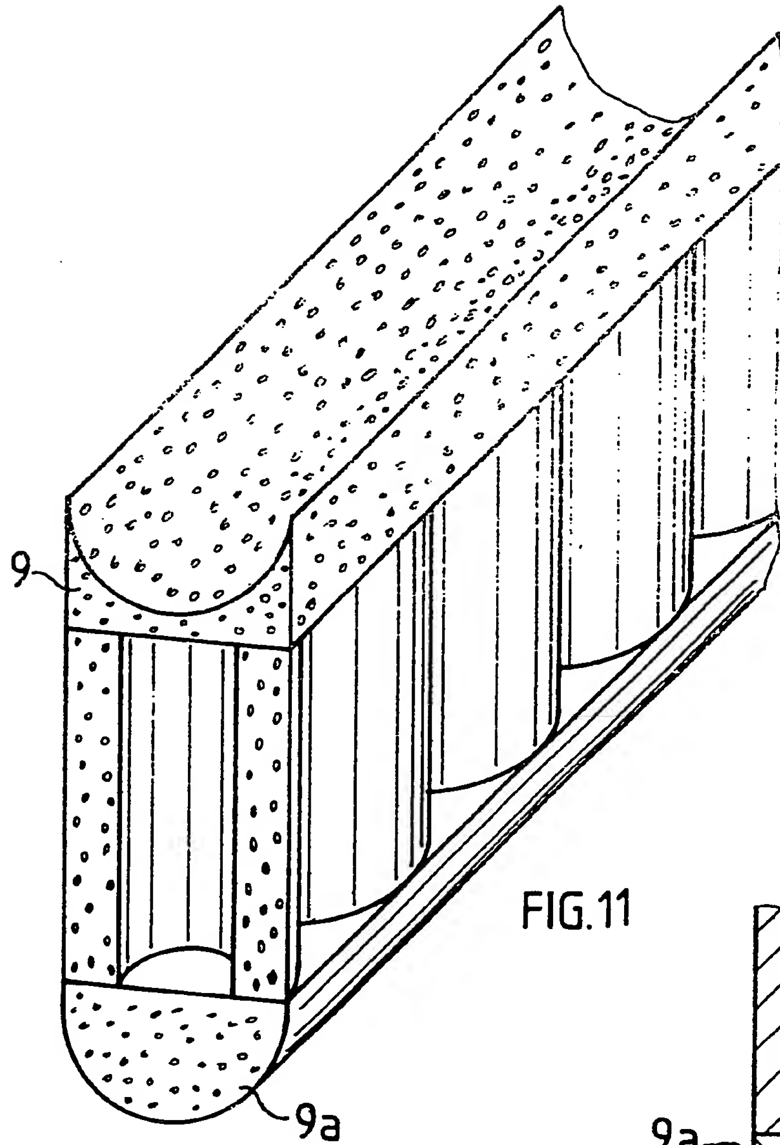


FIG.11

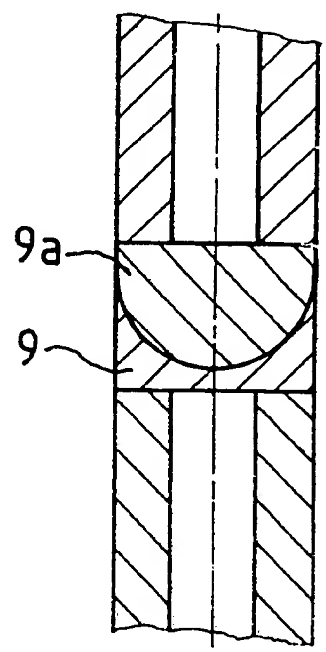


FIG.11a

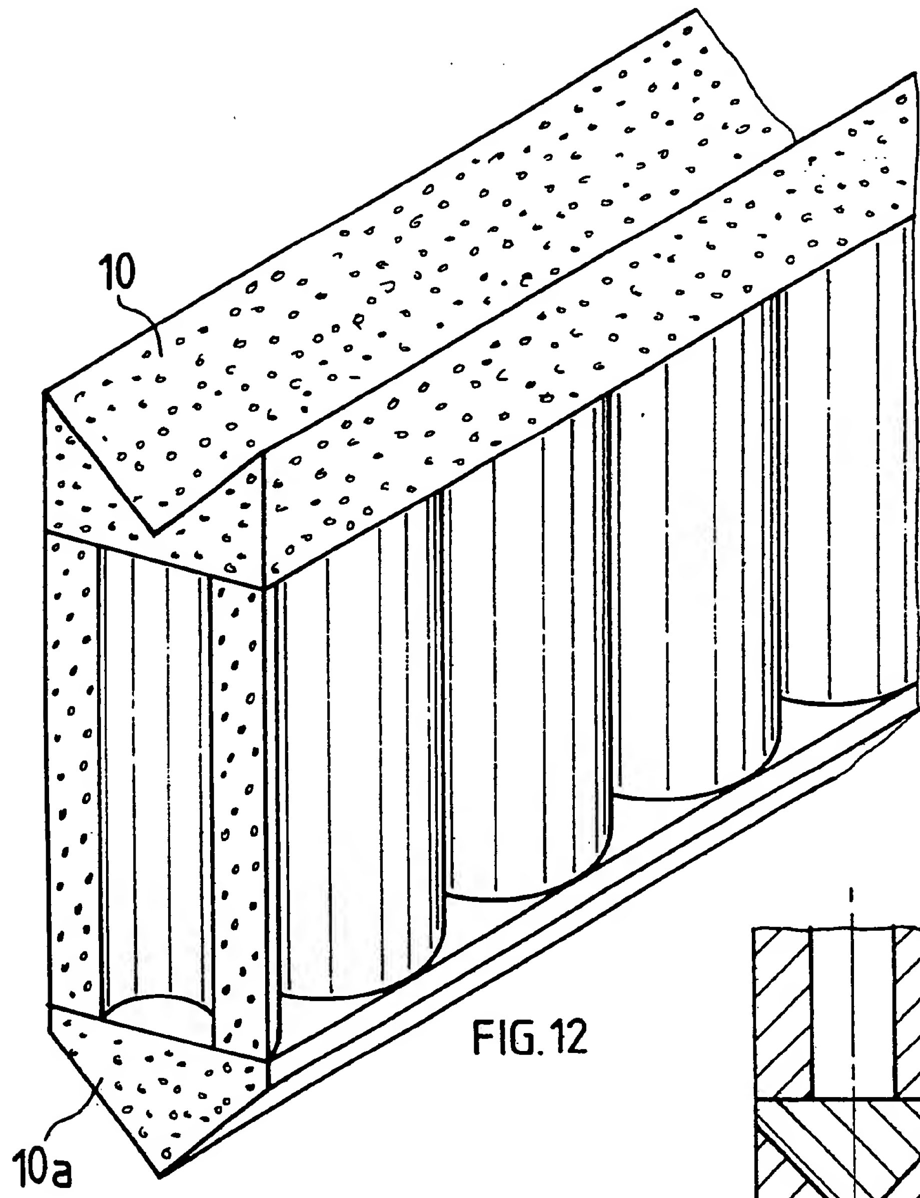


FIG.12

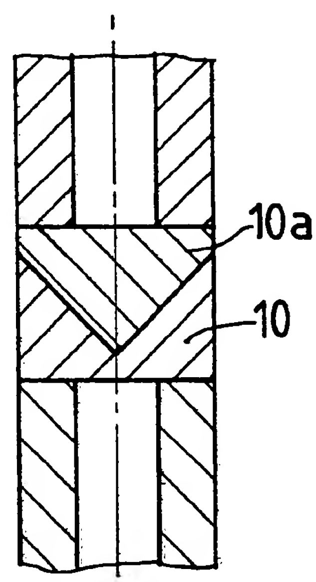


FIG.12a

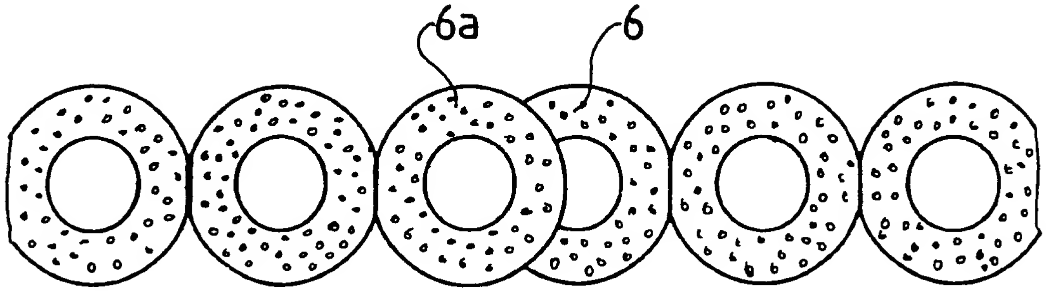


FIG.13

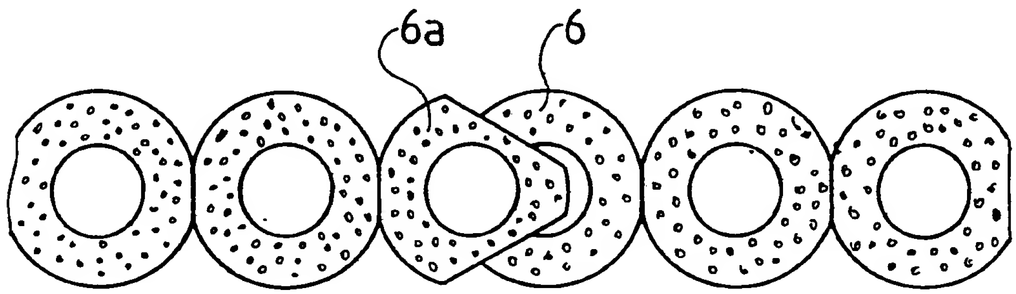


FIG.14

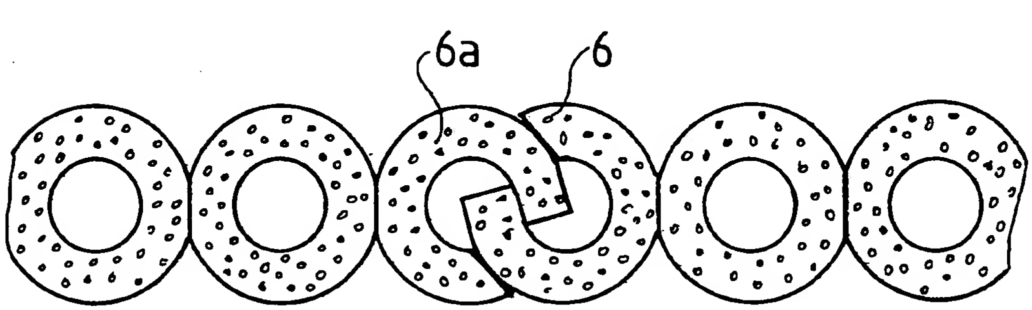


FIG.15

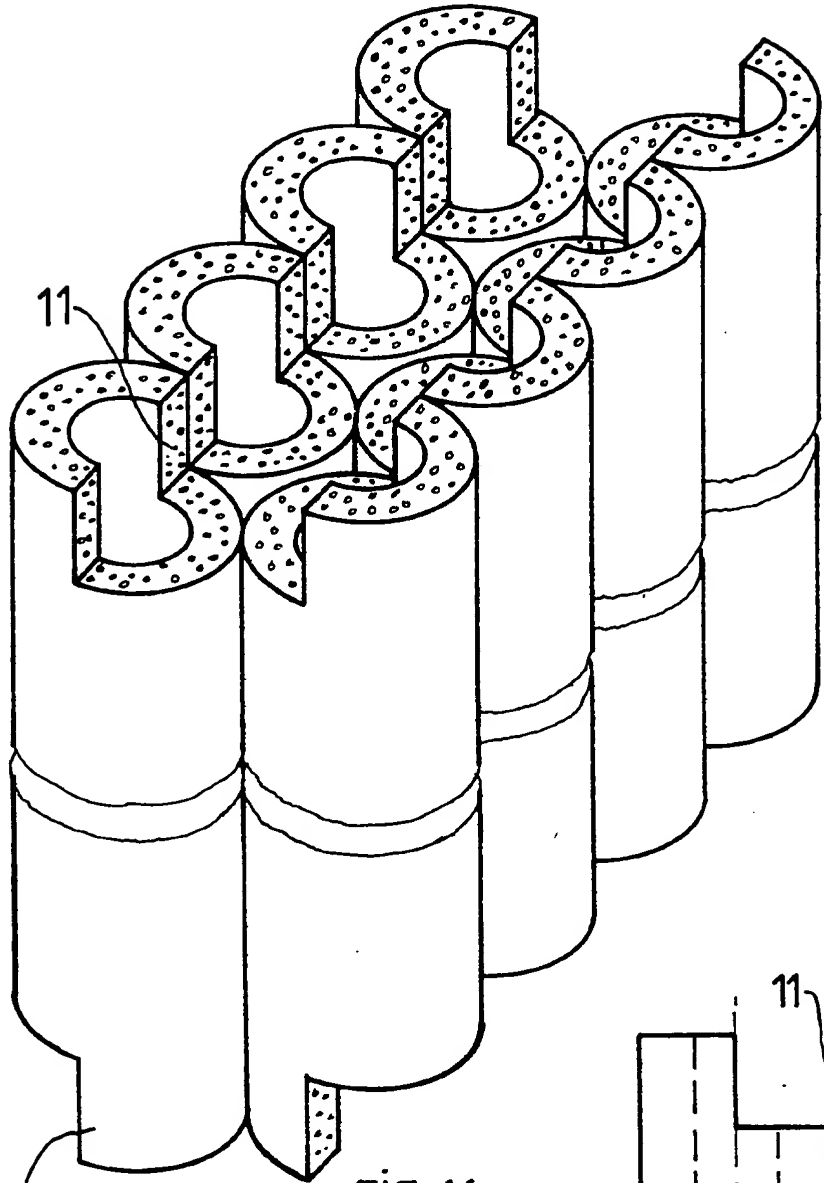
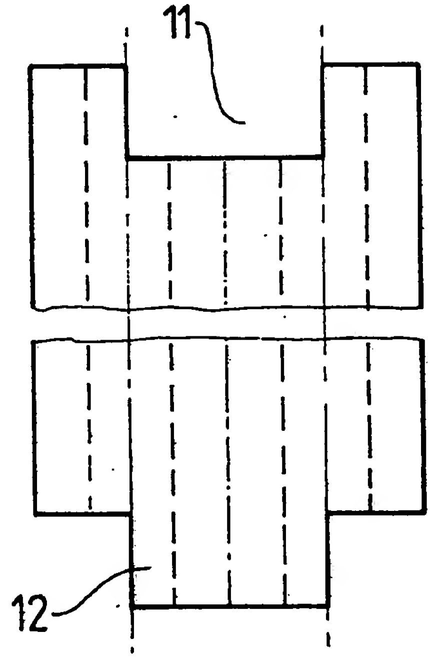


FIG. 16



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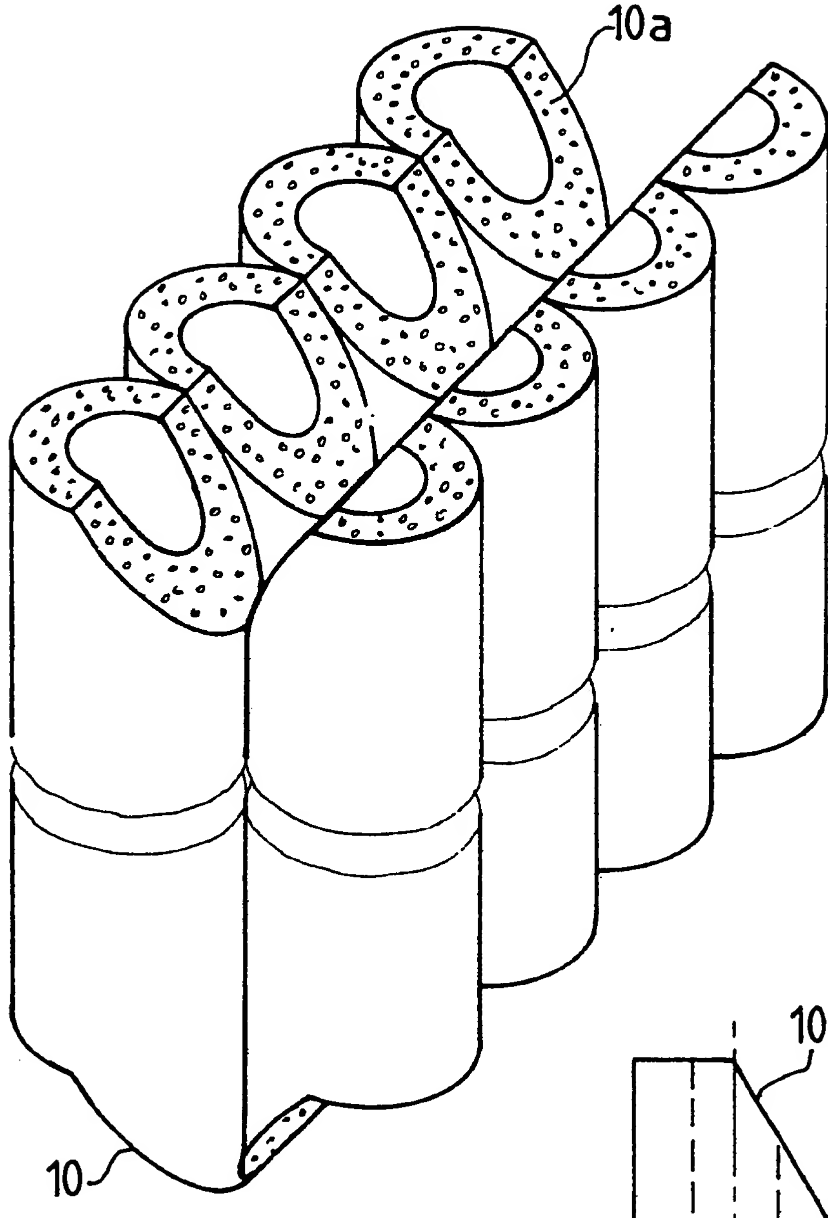

FIG.17

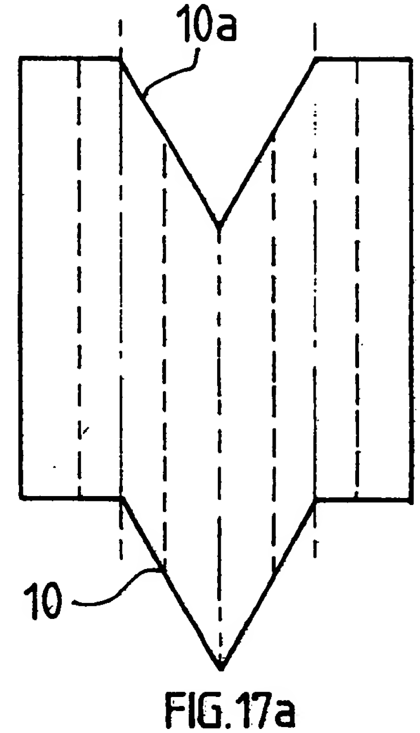

FIG.17a

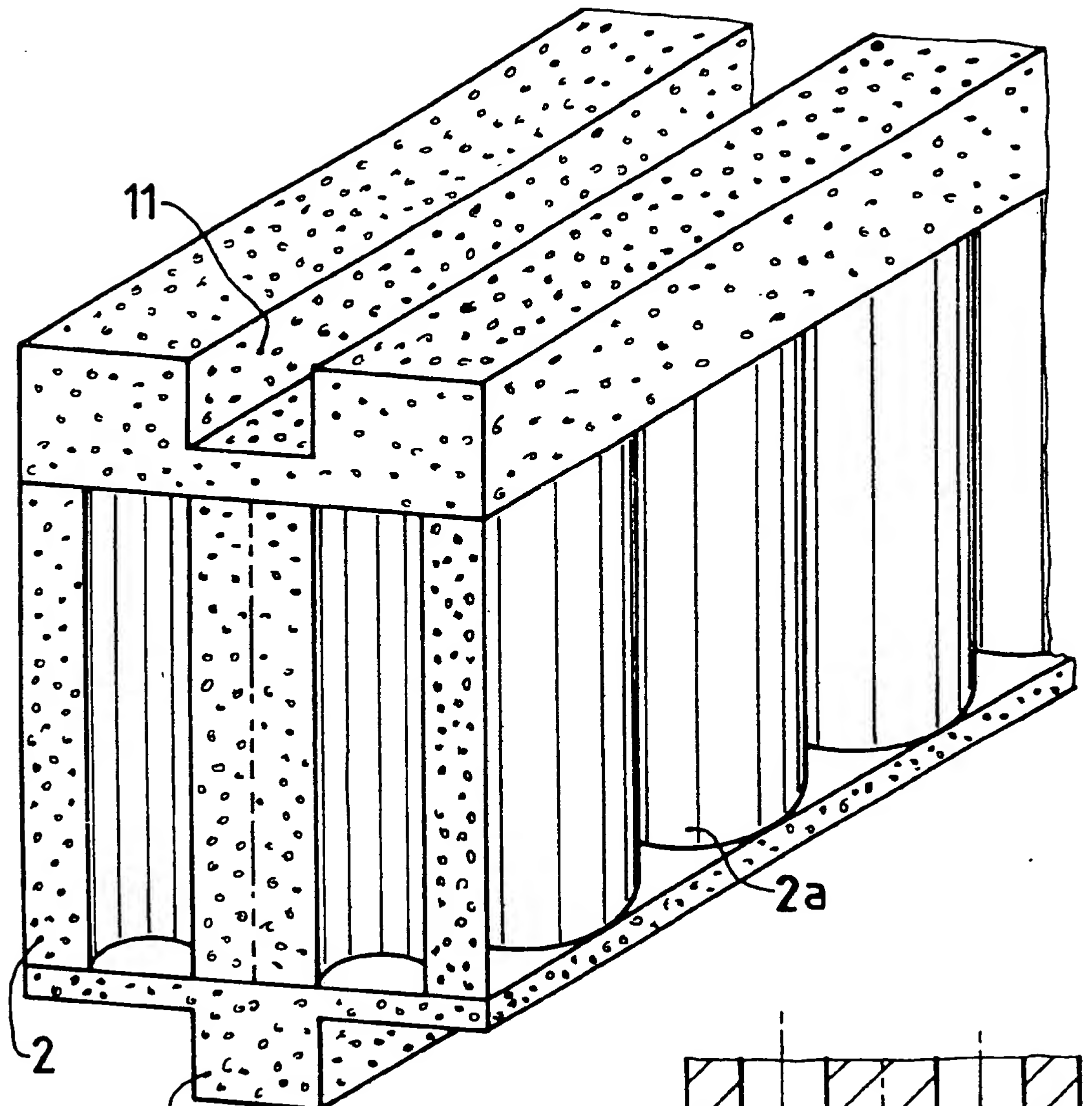

FIG. 18

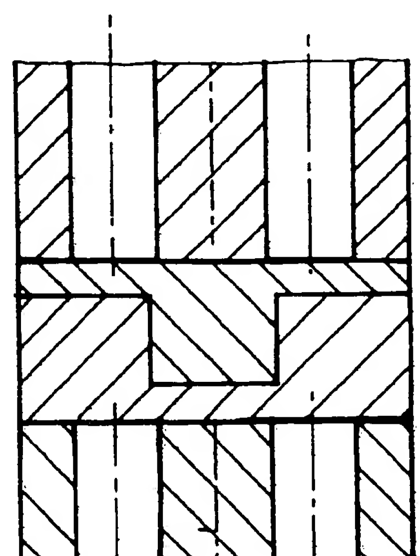

FIG. 18a

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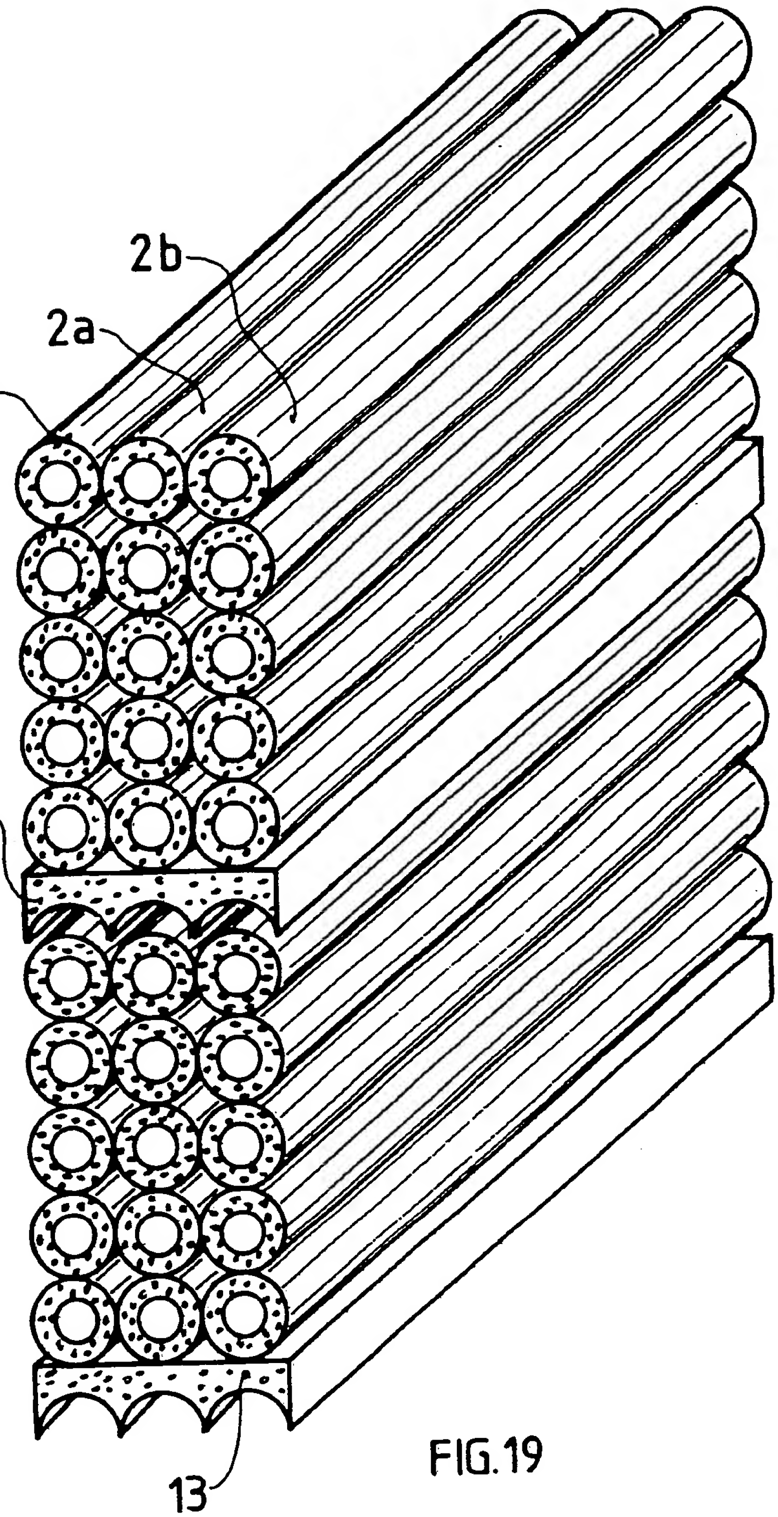

FIG.19

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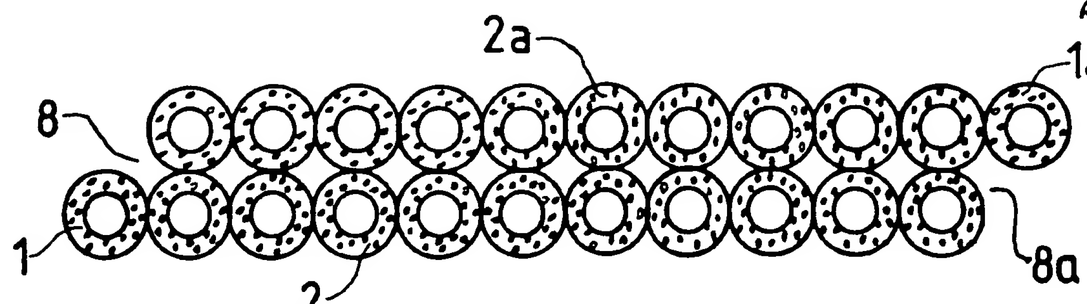

FIG. 20

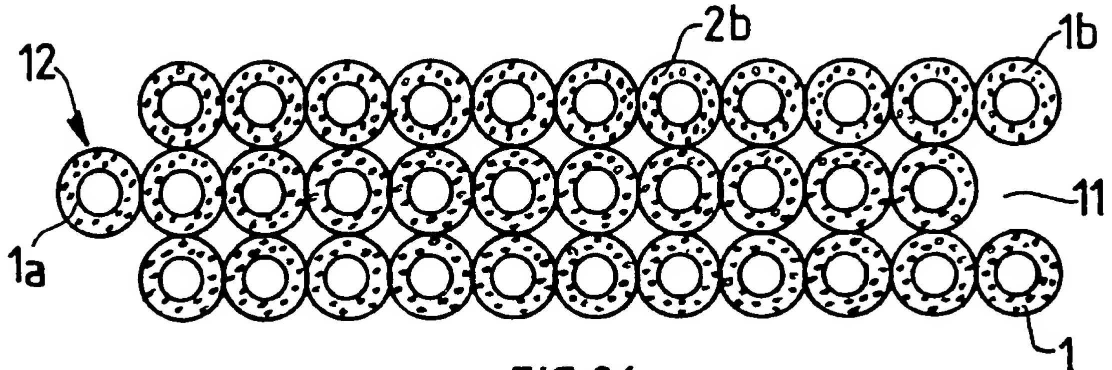

FIG. 21

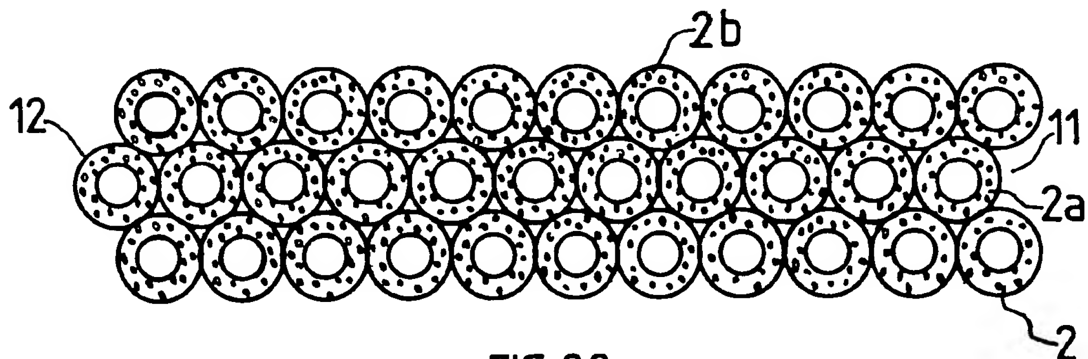

FIG. 22

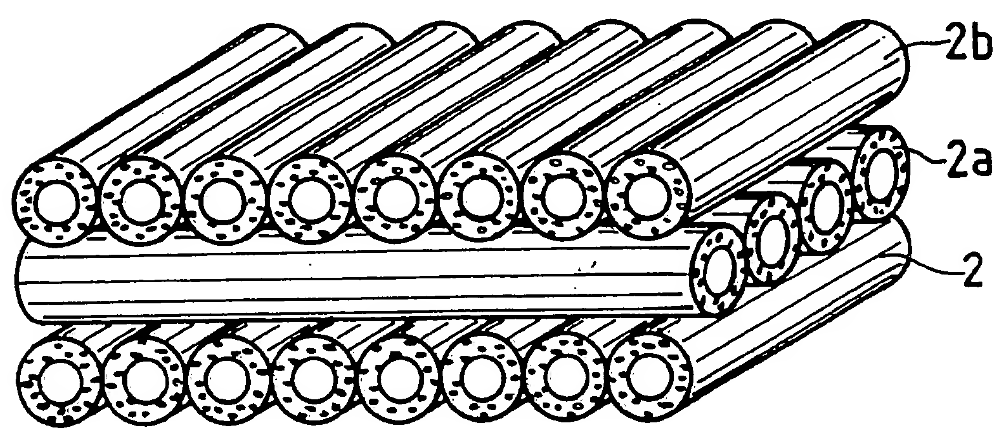

FIG. 23

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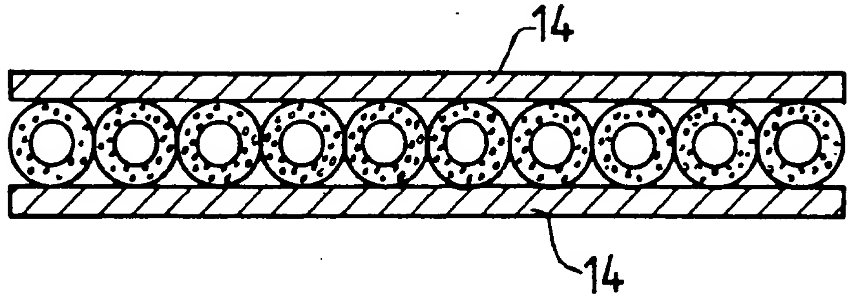


FIG. 24

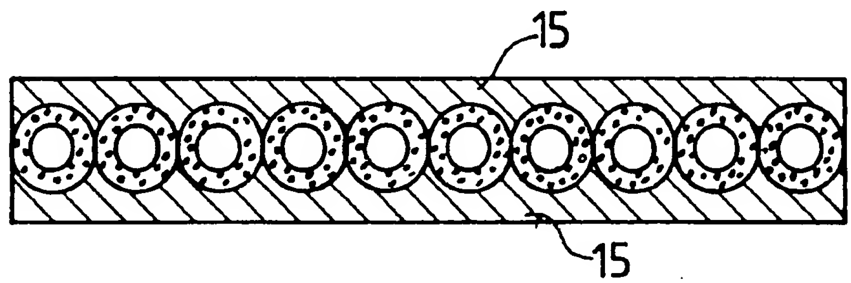


FIG.25

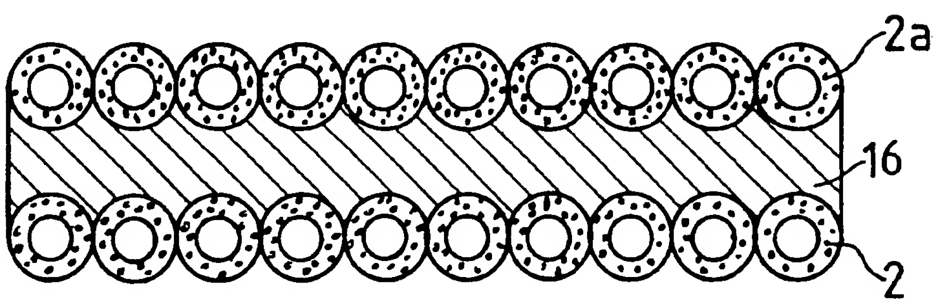


FIG. 26

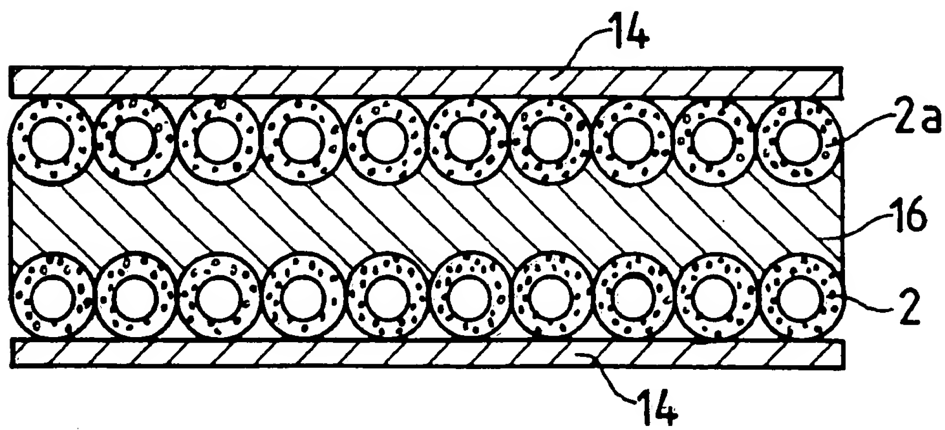


FIG.27

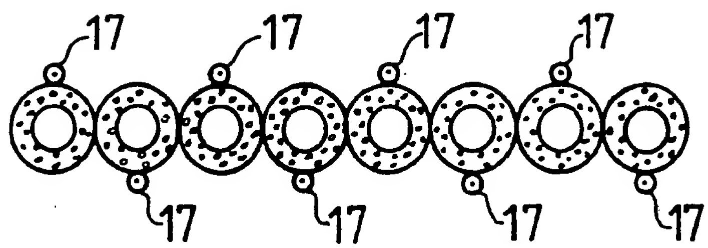


FIG. 28

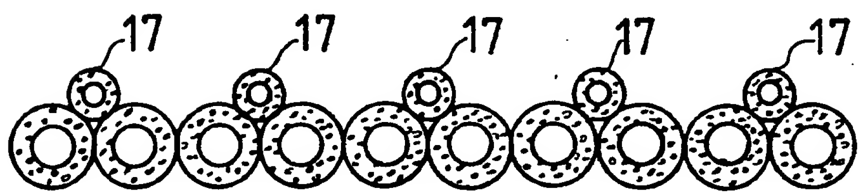
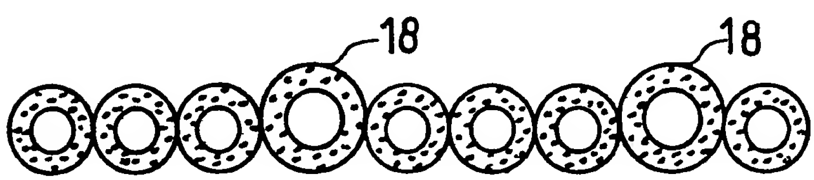


FIG. 29



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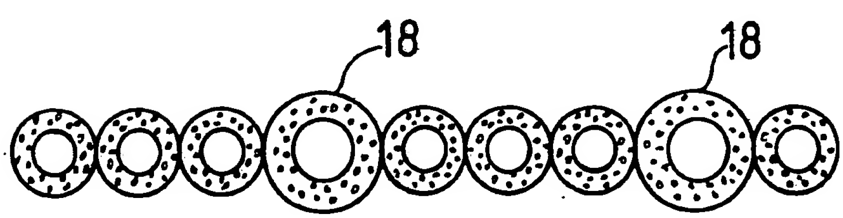


FIG. 31

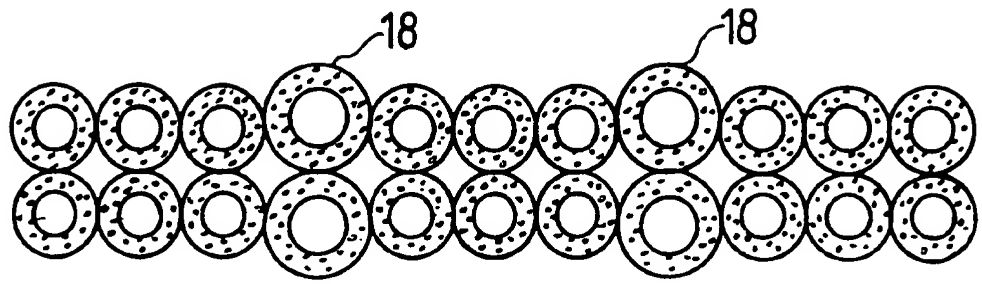
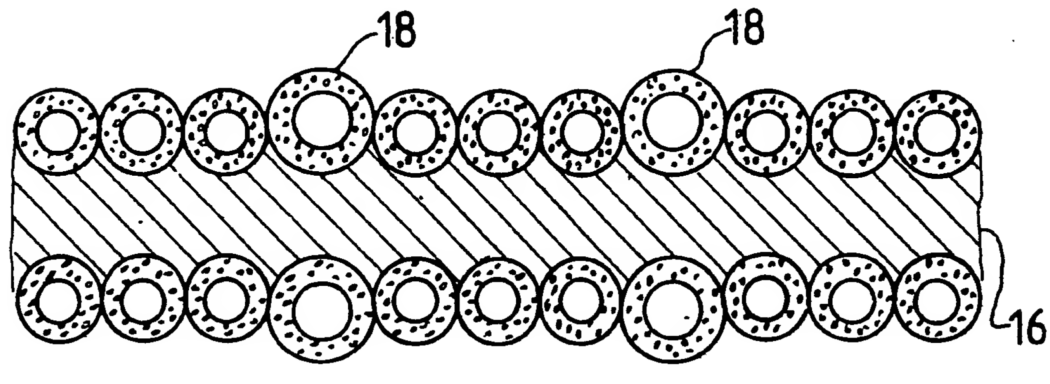


FIG.32



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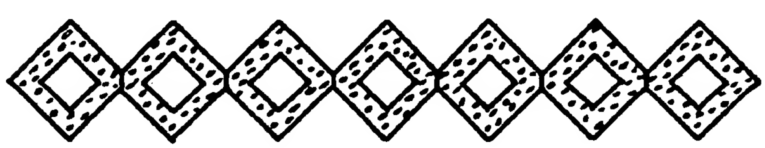

FIG. 34

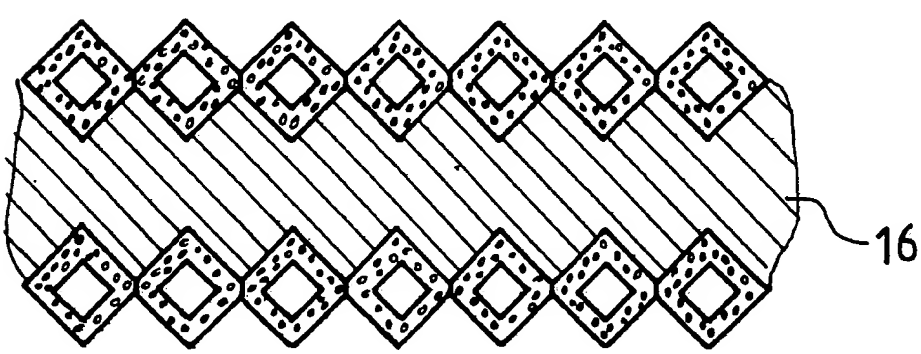

FIG. 35

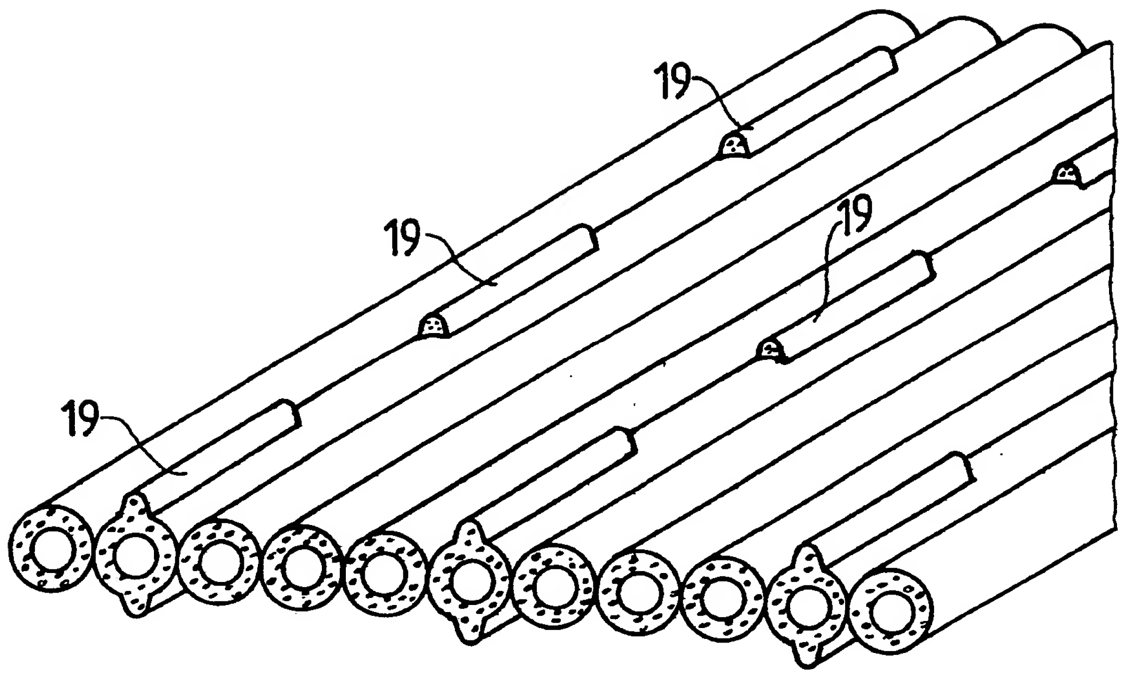

FIG.36

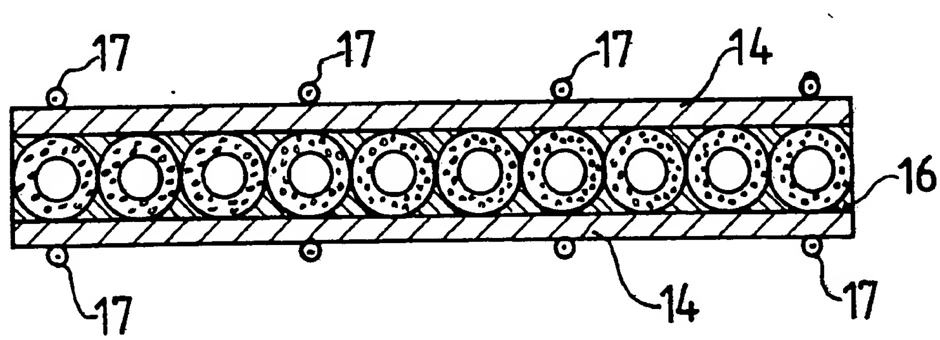

FIG. 37

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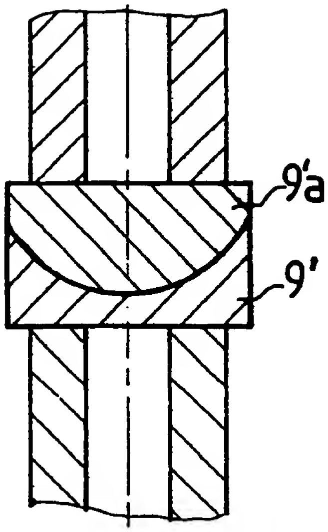

FIG.38

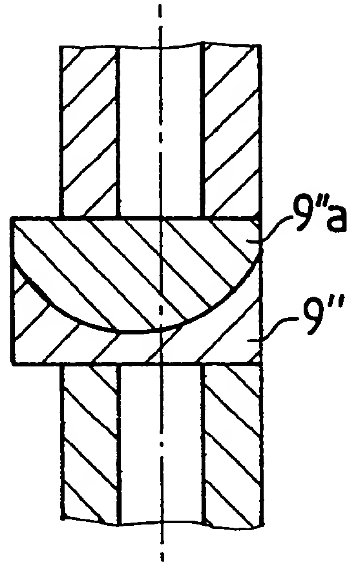

FIG.39

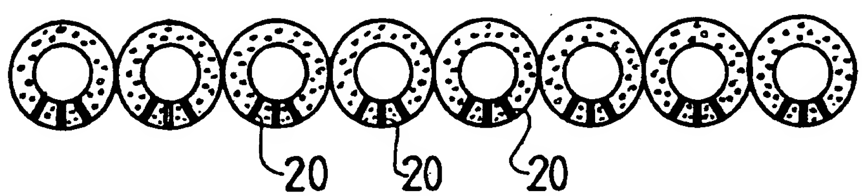

FIG. 40

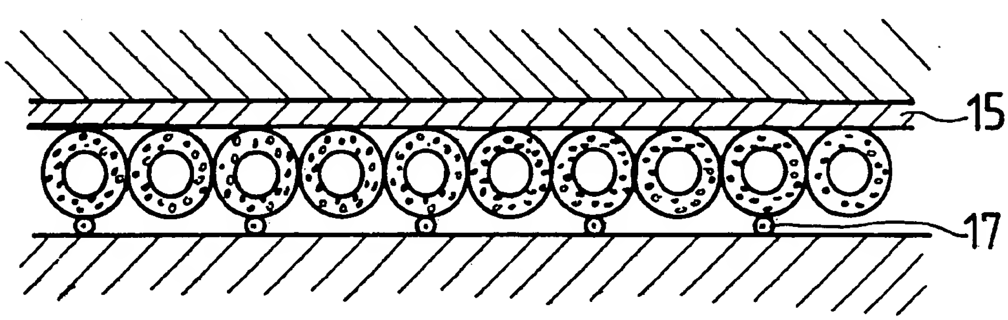

FIG. 41

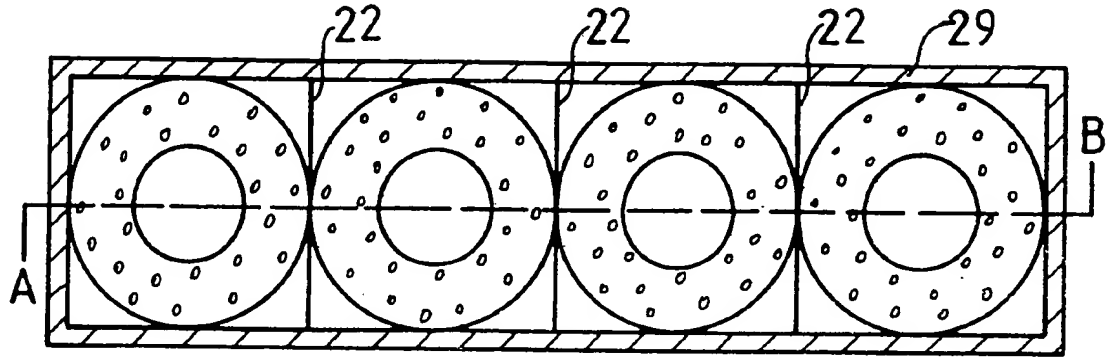

FIG. 42

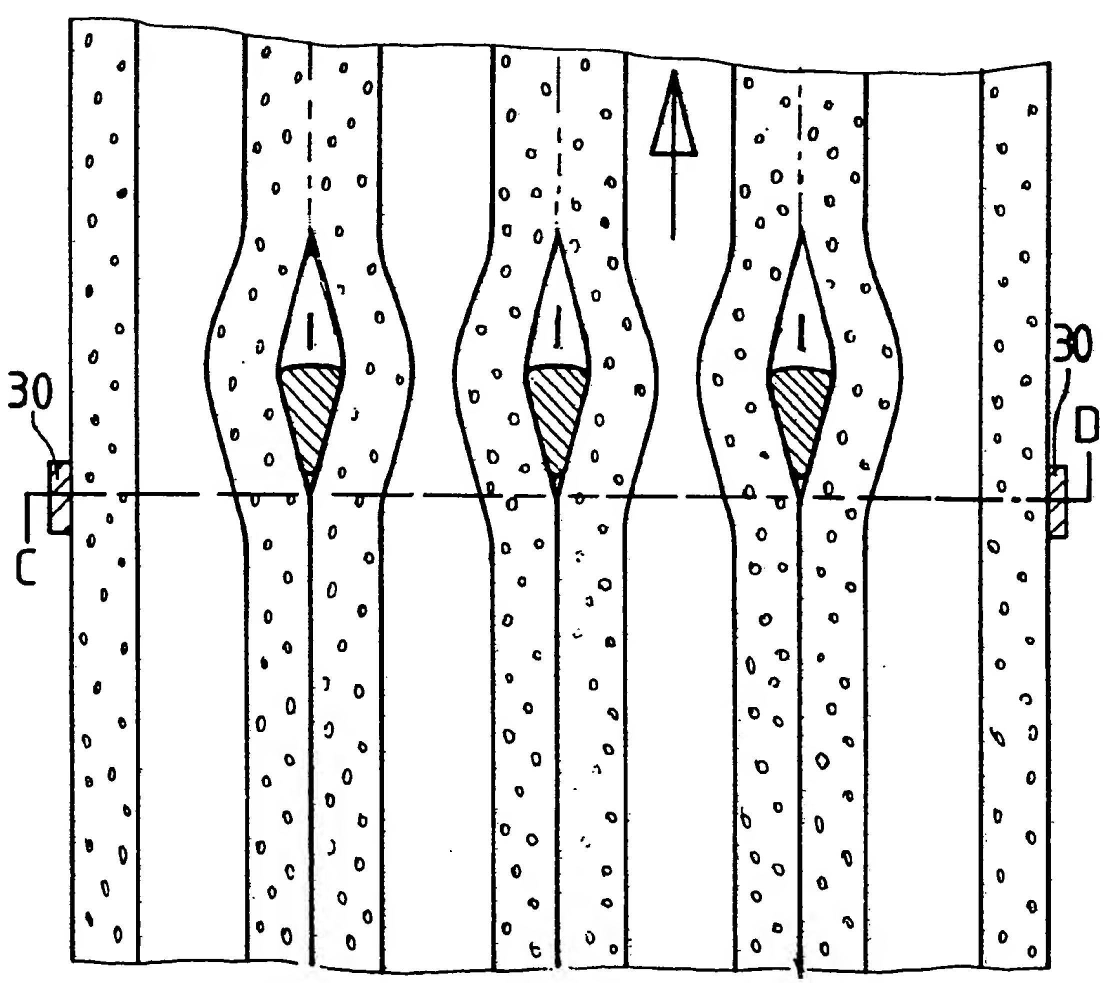

FIG. 43

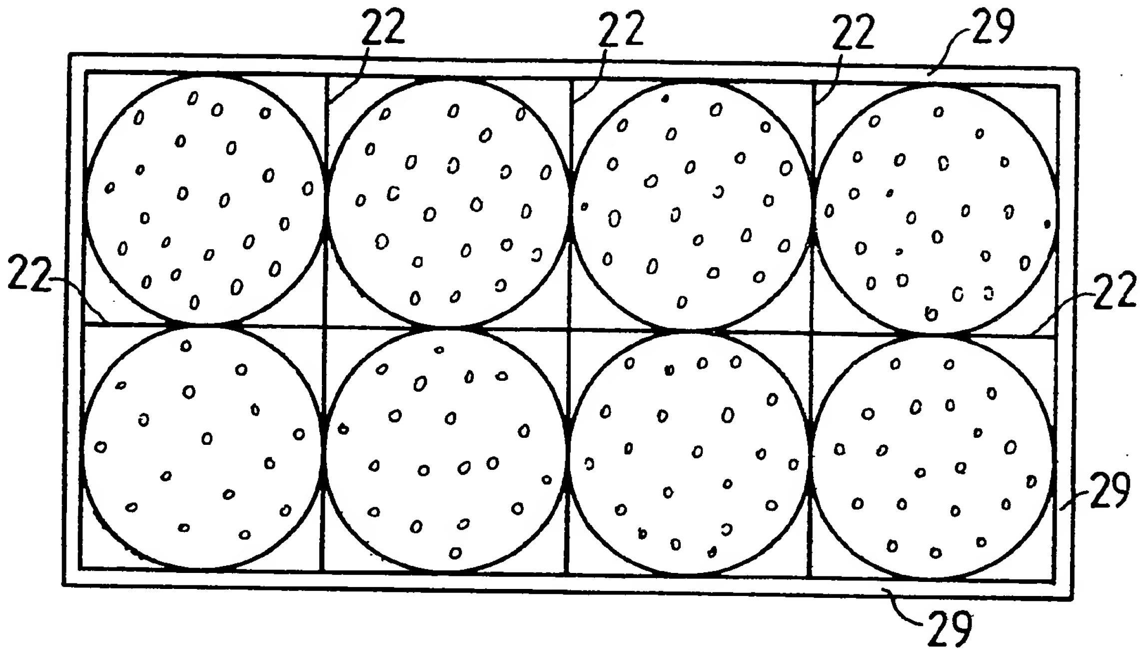

FIG. 44

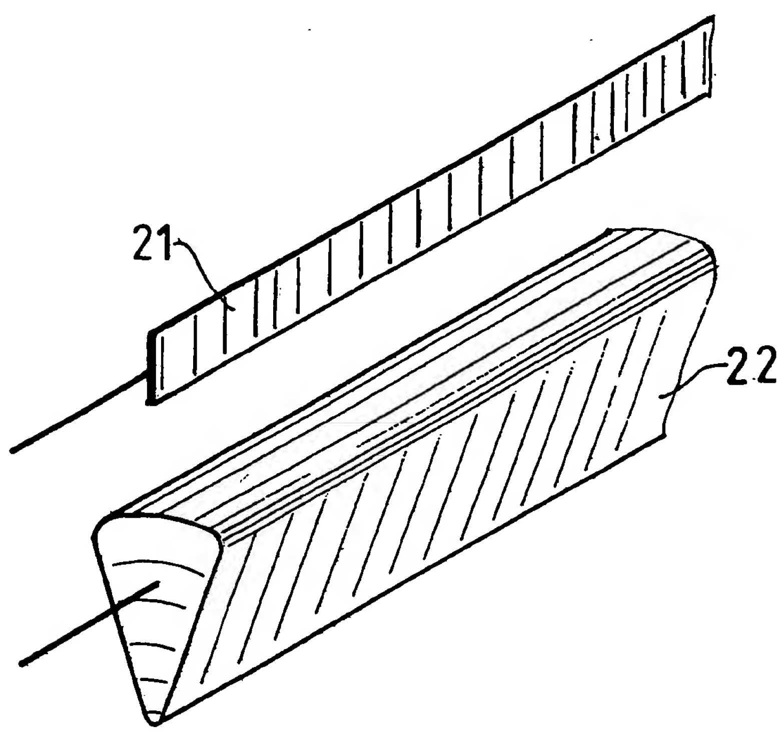

FIG.45

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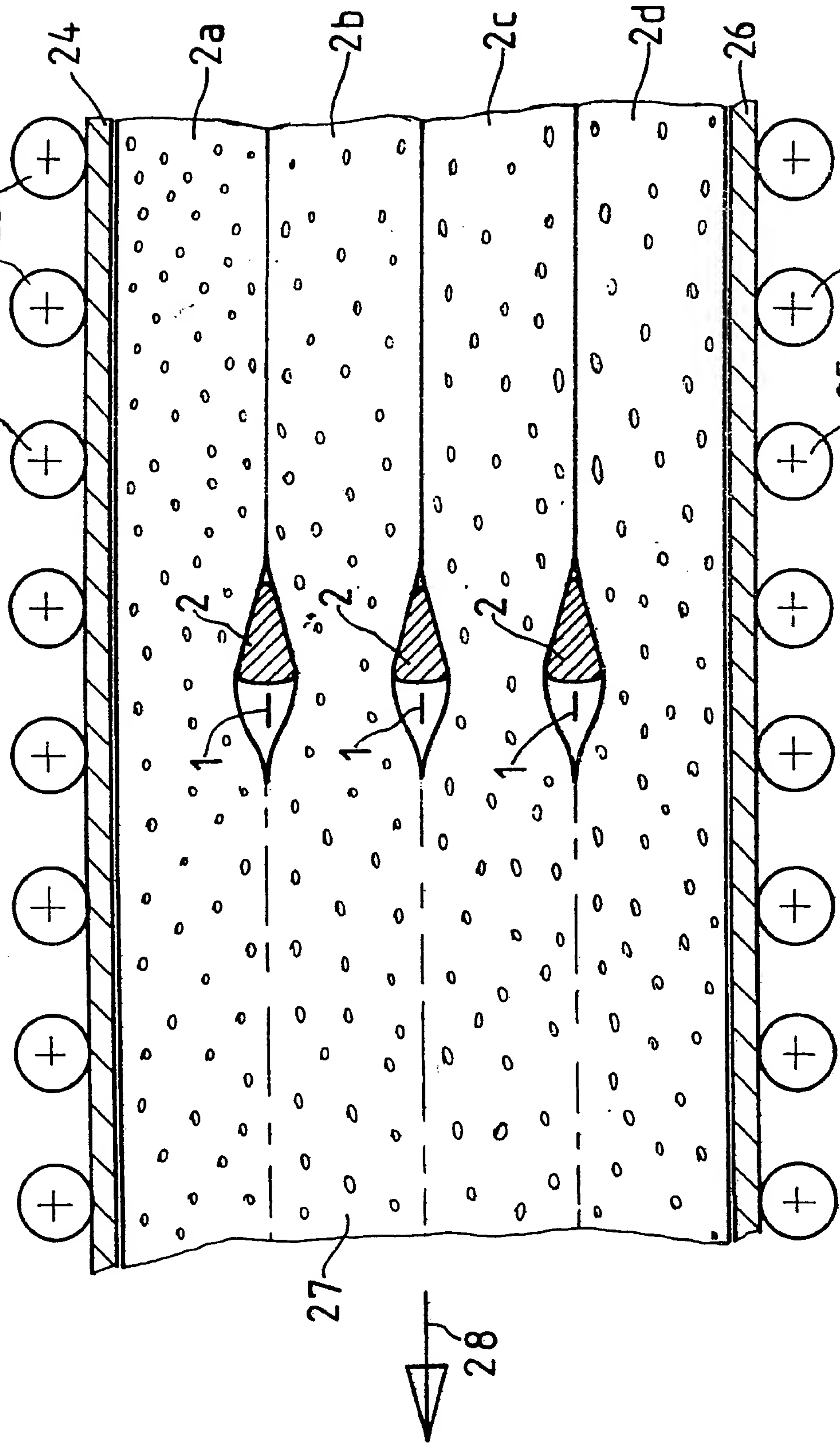

FIG.46

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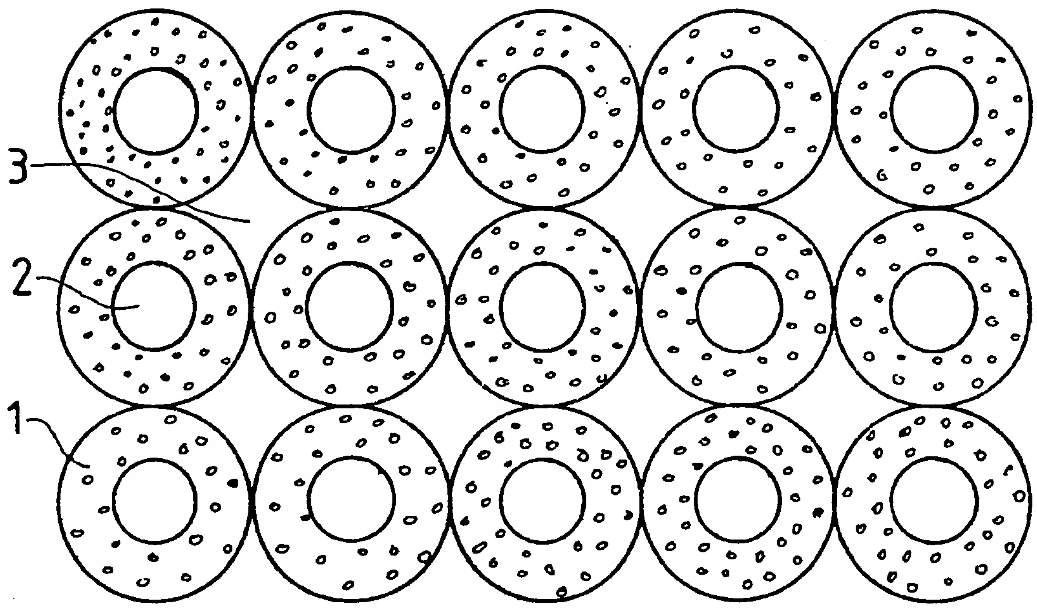

FIG. 47

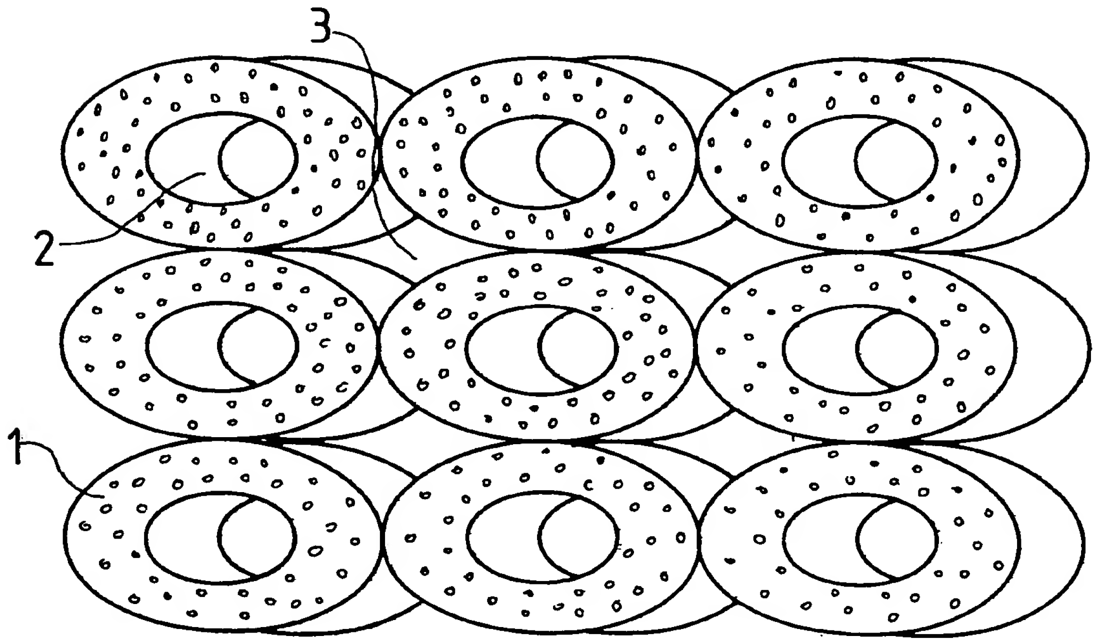

FIG. 48

SPECIFICATION

Foam panels and bl cks of holl w profiles, the manufacture thereof, and the use thereof as insulating and/or drainage panels

The present invention relates to foam panels and/or blocks of synthetic resin material.

Foam panels or blocks made of synthetic resin material have been known. They range from rigid to highly elastic, they may consist of a wide variety of materials, their volume weights may vary widely, i.e. they can be relatively high, e.g. 800 kg/m^3, or relatively low, e.g. 30 kg/m^3. For purposes of thermal insulation especially foam materials are employed which are of very light weight and have a closed cell structure of very fine cells, if possible. Examples for such foams are polyurethane foams or polystyrene foams, but also foams produced from polyolefins, especially polyethylene.

The continuous manufacture of very lightweight foam panels or blocks is relatively complicated and is possible only up to certain minimum volume weights.

Therefore, it is an object of the present invention to provide foam panels or blocks which can be manufactured relatively easily and which have very low volume weights, based on the total volume thereof. Moreover, it is a further object of the present invention to form the edges of the foam panels of the present invention so that, when assembled, they mutually secure each other in position, and the height of the air column determined by the inner voids of the hollow profiles can be limited to the panel dimensions by corresponding blockage.

According to the invention, this problem is solved in that hollow foam profiles are adhered and/or welded to one another and optionally their lateral edges are profiled. Preferably the hollow foam profiles employed are insulating foam tubes, especially tubes having a volume weight of less than 20 kg/m^3. Instead of normal insulating foam tubes having round cross section it is possible, according to the invention, to use any other imaginable hollow profiles, e.g. tubes with square, rectangular or oval cross section.

Preferred embodiments of the foam panels of the invention include panels described in the subclaims and explained in more detail hereafter with reference to Figs. 1 to 46.

The foam panels and blocks according to the invention are produced in that the hollow foam profiles are glued together, bonded by solution welding or by thermal welding. A thermal welding method especially suited for the purposes of the invention is described in the second part of this description. Furthermore, it is possible to weld the extruded hollow foam profiles in situ, as is also described briefly in the second part of this description.

The invention will n w be explained at first with reference t th figures, without being limited thereto. All the details apparent from the figures belong to the disclosure of the present invention and are regarded as essential to the invention, even if one or the other detail should not be discuss d h reafter. In the figures and in the foll wing explanati ns the indicated r ference numerals hav th following meanings:

1	foam tubes
2, 2a, 2b, etc	tube panels each formed from a series of foam tubes disposed side by side
3, 3a	shorter panel edges of the foam panel
4, 4a	longer panel edges of the foam panel
5, 5a	panel edges on the sides formed by the open tube ends
6, 6a	panel edges on the sides formed by the tube walls
7, 7a	homogeneous or foamed film or sheet strips
8, 8a	stepped edge
9, 9a	round edge
9', 9'a	round edge profile bar with spacer function on both sides
9", 9"a	round edge profile bar with one-sided spacer function
10, 10a	wedge-shaped edge
11	groove
12	tongue
13	triple round edge profile bar
14	laminated facing layers
15	foamed facing layers
16	foamed interlayer
17	foam tubules or rods as spacers
18	larger tubes as spacers
19	tubes with rib as spacers
20	drainage holes
21	electrically heated heat conductor
22	wedge-shaped spacer means
23	rolls for the upper conveyor belt 24 of the twin belt system
24	upper conveyor belt of the twin belt system
25	rolls for the lower conveyor belt 26 of the twin belt system
26	lower conveyor belt of the twin belt system
27	foam panel composed of 4 tube panels
28	arrow indicating the direction of conveyance
29	frame of steel tubing
30	lateral confinement bars

Fig. 1 is a perspective view of a foam panel of rectangular shape in plan view consisting of one layer of short foam tubes arranged side by side in parallel and welded together.

Fig. 2 is a perspective view of a foam panel of rectangular shape in plan view consisting of one layer of long foam tubes arranged side by side in parallel and welded together.

Fig. 3 is a perspective view of a foam panel consisting f two superposed layers of short foam tubes arranged side by side in parallel and welded t g ther.

Fig. 4 is a perspective view of a foam block consisting of five superposed layers of short foam tubes arranged side by side in parallel and welded together.

Fig. 5 is a p rspective view of a foam panel according to Fig. 1 where the panel edges formed by

the tub ends hav a st pp d profile 8, 8a cut out of the tube nds.

Fig. 5a is a plan vi w of th panel dg 6 formed by the tube wall of the first tube in the foam panel.

Fig. 5b is a plan view of the stepped edge 8, 8a as formed when two matching foam panels according to Fig. 5 are put together.

Fig. 6 is a perspective view of a foam panel according to Fig. 1 where the panel edges formed by the tube ends have a round configuration 9, 9a cut out of the tube ends.

Fig. 6a is a plan view of the panel edge 6 formed by the tube wall of the first tube in the foam panel.

Fig. 6b is a plan view of the round edge 9, 9a as formed when two matching foam panels according to Fig. 6 are put together.

Fig. 7 is a perspective view of a foam panel according to Fig. 1 where the panel edges formed by the tube ends have the shape of a wedge 10, 10a cut out of the tube ends.

Fig. 7a is a plan view of the panel edge 6 formed by the tube wall of the first tube in the foam panel.

Fig. 7b is a plan view of the wedge 10, 10a formed when two matching foam panels according to Fig. 7 are put together.

Fig. 8 is a perspective view of a foam panel according to Fig. 1 in which the panel edges formed by the tube ends have a groove 11 and a tongue 12, respectively, cut out of the tube ends.

Fig. 8a is a plan view of the panel edge 6 formed by the tube wall of the first tube in the foam panel.

Fig. 8b is a plan view of the groove-and-tongue joint 11, 12 formed when two matching foam panels according to Fig. 8 are put together.

Fig. 9 is a schematic perspective view of a foam panel according to Fig. 1 whose open tube ends are provided on both sides with a foam strip 7, 7a. In the foreground of the figure the foam panel is cut through along the longitudinal axis of a tube in order to demonstrate the position of the weld.

Fig. 10 is a schematic perspective view of a foam panel according to Fig. 1 whose open tube ends are provided on both sides with a stepped edge profile bar of synthetic resin foam, preferably the same foam from which the tubes are made. When two matching foam panels are put together they form a step joint. In the foreground the foam panel is cut through along the longitudinal axis of a tube in order to demonstrate the position of the profile bars.

Fig. 10a is a cross section through a stepped profile joint.

Fig. 11 is a schematic perspective view of a foam panel according to Fig. 1 whose open tube ends are provided on both sides with a round edge profile bar of synthetic resin foam welded thereto, preferably the same synthetic resin f am as the tub material. When two matching foam panels are put together they form a round edge joint. In the f reground th foam panel is cut through along the longitudinal axis of a tube in order to demonstrate the position of the profile bars.

Fig. 11a is a cross section through a round edge joint.

Fig. 12 is a schematic perspective vi w of a foam panel according to Fig. 1 whose open tube ends are provided n both sides with a wedge edge profile bar f synthetic resin foam welded thereto, preferably the same synthetic resin foam as th tub material. Two matching foam panels put together form a wedge joint. In the foreground the foam panel is cut along the longitudinal axis of a tube in order to demonstrate the position of the profile bars.

Fig. 12a is a cross section through a wedge joint.

In this manner a grooved profile bar can be welded or adhered to one edge and a tongue profile bar, or tongue profile bars of different configuration, can be welded or adhered to the other edge.

Fig. 13 is a section through a panel joint of the round edge type which extends along the panel edges formed by the tube walls 6, 6a, in which the panel edge formed by the tube wall 6a of one tube panel is unchanged, while the panel edge formed by the tube wall 6 of the other tube panel is cut out in a circular arc along the length axis of the tube.

Fig. 14 is a cross section through a panel joint of the wedge edge type which extends along the panel edges formed by the tube walls 6, 6a. One panel edge formed by the tube wall 6 of the one tube panel is cut out in segment form along its longitudinal axis, and the other panel edge formed by the tube wall 6a of the other tube panel is cut out in wedge form so that it extends and fits into the segment-shaped cut in the tube of the other tube panel. The interior cavity of the tube 6a cut to wedge shape is preferably filled with a foam rod, especially a rod of a material more rigid than the tube material.

Fig. 15 is a cross section through a panel joint in which both panel edges formed by tube walls 6, 6a are cut out in segment form along the longitudinal axes so that two matching panels can be hooked together, i.e. the segment-formed gaps are disposed laterally opposite each other, and the size of the segment gaps is equal to or somewhat smaller than the thickness of the tube wall.

Fig. 16 is a perspective view of a foam panel composed of two tube panels according to Fig. 3 in which the panel edges formed by the tube ends show a groove 11 and tongue 12, respectively, cut out of the tube ends.

Fig. 16a is a plan view of the tube edge formed by the two tube walls of the first two tubes in the foam panel.

Fig. 17 is a perspective view of a foam panel composed of two tube panels according to Fig. 3 in which the panel edges formed by the tube ends have a wedge-shaped edge 10, 10a cut out of the tube ends.

Fig. 17a is a plan view of the tube edge formed by the two tube walls of the first two tubes in the foam panel.

Fig. 18 is a perspective view of a foam panel composed of two tube panels according to Fig. 3 in which the panel edges f rmed by the tube ends have a gro ve (11) and t ngu (12) profile bar of synthetic resin foam welded ther to, preferably of the same foam material as the tube material. In the foreground the foam panel is cut along the longitudinal axis of th illustrated tube in order to demonstrat the position of the profile bars.

Fig. 18 is a secti n thr ugh a groove-and-t ngu joint formed by two matching foam panels of Fig. 18.

Fig. 19 is a perspective view of two foam panels

joined one to the other and composed each of three tube panels 2, 2a and 2b welded tog ther, ne panel edge being pr vided with a triple round edge profile bar 13, which together with the three end tubes of the matching other panel edge forms a triple round edge joint. The crosswise edges formed by the tube ends, if desired, can have the above described edge configurations or can form similar types of joints, either by direct cutting or by provision of matching profile bars.

Fig. 20 is a cross section through a foam panel consisting of two superposed tube panels 2, 2a in which the conditions for a stepped edge 8, 8a are provided by welding an additional tube 1 to the left-hand side below and a tube 1a to the righthand side above.

Fig. 21 is a cross section through a foam panel composed of three superposed tube panels 2, 2a and 2b in which a groove 11 and a tongue 12 are formed by welding additional tubes 1, 1a, 1b thereto.

Fig. 22 shows a foam panel like that illustrated by Fig. 21 in which the central tube panel is so arranged that the longitudinal axes of the associated tubes are each disposed in the vertical plane extending through the weld seams above and below. In this case, too, a groove 11 is formed on one and a tongue 12 is formed on the other side.

Fig. 23 is a perspective view of three superposed tube panels, the top and bottom tube panel corresponding to that of Fig. 1, while the intermediate tube panel corresponds to the tube panel of Fig. 2.

Fig. 24 is a cross section through a foam panel with a foam layer 14 laminated to both sides thereof.

Fig. 25 is a cross section through a foam panel onto which a synthetic resin layer 15 has been foamed on both sides.

Fig. 26 is a cross section through a foam panel in which two tube panels 2 and 2a are joined together by way of a foam layer 16.

Fig. 27 is a cross section through a foam panel according to Fig. 26 with a foam layer 14 additionally laminated to both sides thereof.

Fig. 28 is a cross section through a foam panel provided on both sides at spaced intervals with spacers in the form of round foam sticks 17 which may optionally have a wire core.

Fig. 29 is a cross section though a foam panel to which smaller foam tubes 17 are welded to serve as spacers.

Fig. 30 is a cross section through a foam panel in which at spaced intervals the standard tubes are replaced by larger tubes 18 which project from one side and in this way perform the spacing function.

Fig. 31 is a cross section through a foam panel of a structure similar to that of the foam panel in Fig. 30 except that the larger tubes 18 are so arranged that they project uniformly fr m both sides and in this way can perform the spacing function in two directions. Of course, also a m dification is imaginabl where said larger foam tubes 18 project more from one side than from the other side.

Fig. 32 is a cross section through a foam panel composed of two tube panels according to Fig. 30 in which the larger tubes 18 again perform the spacing function.

Fig. 33 is a cross section through a composite f am panel in which two tube panels according to Fig. 30 are joined by a foam int rlayer 16. Here, too, the larger tubes 18 serve as spacers.

Fig. 34 is a cross section through a foam panel of quadrangular hollow profiles joined cornerwise. The free corners of said panel serve as spacers.

Fig. 35 is again a cross section through a composite panel, this time composed of two panels according to Fig. 34 which are joined together by way of a foam layer 16. The free corners of the panels composed of the quadrangular hollow profiles again function as spacers.

Fig. 36 is a schematic perspective view of a foam panel in which foam tubes having generally the same diameter as the other foam tubes are arranged and additionally carry a rib 19 on top and on the bottom; said rib may be cut away or pressed down in places, and the length of the ribs may vary. The ribs again serve as spacers. Of course, among said ribbed tubes also embodiments are possible which carry the rib on only one side.

Fig. 37 is a cross section through a foam panel with a facing layer 14 on both sides joined to the tube panel by means of foam 15. Moreover, on the homogeneous facing layers there are provided at spaced intervals round foam rods 17, optionally with a wire core, as spacers.

Fig. 38 shows a section through two panel edges having round edge profile bars 9', 9'a welded thereto. Said round edge profile bars are larger than the tube diameters so that they uniformly project on both sides and in this way act as spacers on both sides.

Fig. 39 likewise is a section through a round edge joint between two panels in which, however, the round edge profile bars 9", 9"a are welded to the tube so that they project on only one side as spacers.

Fig. 40 is a cross section through a foam panel provided on one side with drain holes 20.

Fig. 41 demonstrates the use of a foam panel provided on one side with a foam layer 15 and on the other side with spacers 17 and disposed in the space formed in an external building wall between the external wall proper and the facing provided in front thereof. The foam layer 15 comes to lie against the wall constituting the supporting wall, while the spacers lie against the curtain wall which may consist, for example, of klinker bricks.

Fig. 42 is a vertical section through a lattice arrangement according to the invention with three welding apparatuses along the line C-D in Fig. 43 for welding foam tubes together which are disposed side by side and which, in practice, is so designed that—depending on the tube diameter—ten to twenty tubes can be welded together simultaneously in one plane.

Fig. 43 is a horizontal longitudinal section along the line A-B in Fig. 42.

Fig. 44 is a vertical section through a lattice arrangement according to the invention with one horizontally and three vertically disp sed w lding means for simultaneously welding foam tubes arranged side by side and one above the other.

Fig. 45 is a schematic perspective view of the wedge-shaped embodiment of the spacer means

preferred acc rding to the invention and thereabov an electrically heated h at conduct r in the form of a metal strip.

Fig. 46 is a vertical longitudinal section through the welding apparatuses arranged according to the invention in a twin belt system for welding together the tube panels 2, 2a, 2b and 2c.

According to the invention, the hollow profiles and the tube panels are welded together, and the edge profile bars and individual tubes are welded to these structures preferably in a process which is characterized in that the synthetic resin surfaces to be heated up to melting temperature are guided over a spacing means at a distance around the electrically heated heat conductor serving as heat source in such a way that the synthetic resin surfaces to be welded, together with the spacer means, form a heating channel surrounding the heat source, and said heating channel can optionally be closed at its forward and rearward end. To carry out this process an apparatus is used which is characterized in that it comprises at least one electrically heatable heat source, a spacer means provided in front of each of said heat source(s), and a means for pressing the superficially molten surfaces together.

The materials to be welded together according to the present invention may consist of any desired thermoplastic synthetic resin. However, the process of the invention is preferably carried out with thermoplastic synthetic resin materials that can be bonded together only insufficiently by adhesives or by solution welding, i.e., for example, polyolefins, such as polyethylene, especially low-density polyethylene in the form of foams preferably of a density of less than 50 kg/cm^3, especially less than 20 kg/m^3.

The apparatus serving to carry out the process of the invention essentially consists of a heat source, a spacer means arranged in front thereof, and a means, arranged downstream of the heat source, for pressing the superficially molten surfaces together. The heat source preferably consists of an electrically heatable heat conductor, especially in the form of a wire or metal strip. Preferably the wire or the metal strip consists of a chromium-nickel alloy, a chromium-nickel-aluminum alloy, or an iron-chromium-nickel alloy. Of course, also all other metals or metal alloys, or non-metallic heat conductors, e.g. silicon carbide heat conductors, may be employed which are commonly used as resistance heating means. The temperatures to which the heat conductor is heated varies within a wide range, e.g. from 600 to 1200°C, and depends on the material to be welded and the speed at which the synthetic resin surfaces are guided past the heat conductor. At high speeds of travel and/or with high-melting thermoplastic synthetic resins it may be advantageous or necessary to arrange two or more heat conductors in seri s in the direction of travel of the synthetic resin surfaces to be welded together. In order to avoid sagging of the heat conductors, and thus non-unif rm heat radiation, it is preferred according to the invention to always hold the heat conduct rs taut, especially when in the form of wires or metal strip, also when they are hot. The tensioning means, which pref rably also serves as power supply connector, favorably utilizes the lastic force of a tension r compression spring. According to a preferred embodiment, the p wer supply can be controlled or regulated by means of a thermocouple provided in the vicinity of the heat conductor.

In order to form a heating channel, and in order to guide the synthetic resin surfaces to be welded together past the heat conductor at a certain distance from and out of direct contact with said heat conductor, a spacer means is provided shortly ahead of the heat conductor. Said spacer means preferably is wedge-shaped and so arranged that the sharp edge of the wedge is oriented towards the oncoming material, while the back of the wedge faces the heat conductor. The length of the wedge and of the heat conductor depends on the width of the areas to be welded together. The sharp edge of the wedge is preferably slightly rounded in order not to hurt the oncoming material. The wedge back is preferably of convex shape and its longitudinal edges are likewise rounded in order to avoid damage to the material. Of course, the back of the wedge may also be of concave shape; in that case the lateral edges are preferably rounded, too. Since this spacer wedge at the same time serves as a heat shield, it may be suitable to provide the spacer wedge with one or more bores or passages in longitudinal direction to provide a possibility of passing coolant medium through the spacer wedge in case the spacer wedge is in danger of overheating if it is in operation for extended periods of time. For special uses, e.g. when a heating channel substantially closed on all sides is desired, the open space downstream of the spacer wedge can be covered on both sides by a cover extending from the wedge. The wedge flanks are preferably highly polished in order to reduce friction.

According to another embodiment of the invention the spacer means can also be a pair of rolls, and in that case the roll diameter and the roll length must be adapted to the prevailing practical requirements. Pairs of spacer rolls are preferably used according to the present invention in cases where, for example, relatively thick and wide tube panels 2, 2a, e.g. panels of a thickness of 8 or 16 cm and a width of one meter or more, are to be welded together, or in cases where the foam panels of the invention are to be laminated with corresponding homogeneous or foamed film or sheets or other facing layers, in order to minimmize friction between the foam panels and the spacer means. Also with the use of pairs of spacer rolls preferably supported in ball bearings it may be desirable to cool the rolls. In such cases at least one of the two rolls is hollow and is so constructed that a coolant medium can be passed therethrough.

Hence, by the spacer means it is possible to guide the synthetic resin surfaces to be welded together at a distanc past th heat source to ther by superficially melt the synthetic resin surfaces.

Shortly aft r having passed by the heat source th molten surfaces are compressed by means of suitable devices, e.g. by pressur r lls. After the material has cooled d wn the welding operation is terminated.

According to the present invention, foam tubes made of low-density polyethylene having volume

weights of less than 50 kg/m^3 or 20 kg/m^3, respectively, can be welded t gether to form panels of any desired width. The width of the tube areas which are welded together can be varied by accordingly compressing the foam tubes, e.g. by varying the distance between the juxtaposed welding means of the invention, the dimensions of the spacer means, and the nip between the pressure rolls which may be provided downstream of the heat source. Since the welding means of the invention can be arranged not only side by side but also one above the other, the foam tubes can be simultaneously welded together side by side and one above the other by means of such a lattice welding system, so that the panels or blocks composed of the foam tubes are obtained.

Furthermore, according to the present invention it is possible in a continuous mode of operation, for example with a twin belt system in which the welding means of the invention is integrated, to produce sandwich elements having a polyethlyene foam core which otherwise can be adhesion-bonded only with difficulty (if at all) and metallic or other facing layers to which the molten polyethylene firmly adheres.

According to the present invention, the foam tubes are welded together by the mode of operation illustrated by Figs. 42 to 44. At the frame 29 assembled, for example, from steel tubing (cf Figs. 42 and 44) the wedge-shaped spacer means 22 are disposed in vertical arrangement (see Fig. 42) and in Fig. 44 additionally in horizontal arrangement, with their wedge blades visible in Figs. 42 and 44. In the middle behind the wedge-shaped spacer means the associated heat conductors 21 are arranged (see Figs. 43 and 45) which are always held taut by means of spring tensioning devices, not shown. The spaces between the wedge-shaped spacer means 22 and the lateral confining bars 30, whose distance from one another decreases somewhat in the direction of travel, are preferably so selected that the foam tubes, after having travelled past the welding means, fuse together over a wide area. In order to exert additional pressure on the superficially molten tube walls there is preferably provided, shortly behind the welding means and across, i.e. normal to the direction of travel, a pair of rolls whose rolls are spaced apart from each other and between which the foam tubes are guided.

As shown in Fig. 42, a plurality of welding apparatuses can be arranged side by side so that 20 foam tubes, for example, can be easily welded together to form a tube panel 2. The same applies to the "lattice system" illustrated by Fig. 44 by which a plurality of tubes disposed side by side and one above the other can be simultaneously welded together, for example to form a square block. In view of practical considerations, however, it may be advantageous to simultaneously w ld together 10 or 20 foam tubes disposed side by side, as shown in Fig. 42, and thereafter to weld the thus obtained tube panels 2, 2a, 2b etc one above the other, as shown in Fig. 44, without the vertically arranged welding means, or with the use of the twin belt system shown in Fig. 46 which will be described hereafter.

Fig. 46 is a vertical longitudinal section through part of a twin belt system with upper conveyor belt 24 guided along rolls 23 and lower c nv yor belt 26 guided along rolls 25. Between the upper and l w r conveyor belt 24, 26 there are four layers of tubes 2, 2a, 2b and 2c to be welded together which, after having moved past the wedge-shaped spacer means 22 and the electrically heated heat conductors 21, are welded together to form a foam panel 27. The arrow 28 indicates the direction of travel. Depending on the desired thickness of the welded panels or blocks, several welding apparatuses of the invention can be disposed one above the other or step-wise one after the other in additionally provided corresponding systems. Of course, it is also possible to so design the system that only one welding apparatus is provided, and in that case only two tube panels 2, 2a can be welded together to form the accordingly thicker panel. Moreover, with an accordingly designed system tube panels of different thicknesses can be welded together. The twin belt system can be laterally open, or it can be closed by two additional corresponding conveyor belts likewise moving over rolls. The additional lateral conveyor belts will be provided if lateral evasion of the foam material is to be avoided and thus the pressure for compressing the superficially molten surfaces is to be increased. Normally, i.e. also without lateral conveyor belts, the tube panels—even shortly after the introduction thereof into the twin belt system—are already subject to such high pressure that, owing to their flexibility, they are sufficiently compressed by their own expansion, after having travelled past the welding means.

The foam panels and blocks according to the invention can also be produced by direct extrusion welding. In this continuous process the foamable synthetic resin, preferably polyethylene, is extruded with propellant through suitable nozzles and is allowed to freely foam in the air to form a foam tube. When in this process a multiplicity of nozzles are arranged side by side and/or one above the other in such a way that the foaming tubes contact each other, which happens already very shortly after extrusion through the nozzle, and if care is taken that they are additionally pressed one against the other, for example by suitably arranged pairs of rolls, one obtains the desired foam panels and blocks "in one step". The welding effect can optionally be enhanced by installation of additional heating means directly downstream of the nozzle orifices in order to remelt any external tube skin that may have developed during foaming. Such heating means can be electrically heated wire or metal strip, or devices emitting hot air.

The foam panels welded together in any one of the modes described above are then cut to the desired length so that the cut made, for example, with a hot wire is performed such that the desired edge profile is obtained already when the material is cut to size; in this way no waste is produced because the matching counterpart is btained automatically.

In case the cutting operation in connection with a desired type of edge profile meets with difficulties, the corresponding profile bars can be cut in a simple manner and so that no waste is produced. The profile bars are then welded to the base panel, which may consist of one r two foam tube panels 2, 2a, for

example, by means of the above described welding technique, for exampl .

The f am panels according to the invention are primarily used for thermal insulation in the building industry, especially for application in the spaces of external walls consisting of the supporting wall proper and the curtain wall provided some distance before the supporting wall, for application between the rafters as roof insulation panels, as cast plaster floor insulating panels, and as thermally insulating drainage panels underneath foundations, and as external insulation for underground brickwork.

The foam panels of the invention obtainable according to the invention in a simple way and in any desired density, when used as thermal insulation panels installed in the space between external wall and curtain wall, exhibit the following advantages, inter alia:

(1) The foam can be adjusted to meet existing fire protection regulations.

(2) The lambda values can be adjusted between 0.025 and 0.050, as desired, and depending on the combination and fabrication of the elements, which may range from highly flexible to rigid.

(3) The installation by the mason is simple and foolproof. The panels do not rot.

(4) The foam panels are of light weight and are obtainable at low cost.

(5) The insulation value of vertical and/or horizontal columns having a lambda value of 0.0204 at 0°C is utilized.

(6) They keep the interior-exterior walls "sound" by air columns (condensation balance; "breathing").

(7) They are not sensitive to shaking and vibration; they improve air-borne sound absorption; do not form cold paths; can be cut also at corners; are immune to moisture (pick-up ±0% H_2O).

In a likewise preferred embodiment of the invention the foam blocks produced according to the invention can, in turn, be cut into foam panels having super-light volume weight, namely when cut off the block normal to the longitudinal axes of the tubes, or at any other angle with respect to the longitudinal axes of the tubes.

Such panels are used for the manufacture of quite a number of products, e.g. of gymnastics mats, of high jump cushions, of sandwich elements for sound absorption etc. For this purpose the super-lightweight panels may be used as core and may be laminated with foam or provided with other facing layers. Moreover, super-lightweight composite panels can be produced by alternately welding the super-lightweight panels and solid foam panels.

For the core function also two or more super-lightweight panels can be welded together to again form thicker super-lightweight panels by means of the welding apparatus of the invention, namely such that the super-lightweight panels are superposed in such a way that the h les of on super-lightweight panel are covered by the foam areas of the overlying super-lightweight panel, which can b r alized by accordingly dimensioning the initial foam tubes and optionally also by using, for the manufacture of the super-lightweight panels, foam blocks in which the tube panels are stacked in the manner of th foam panel of Fig. 22.

When in th sup r-lightweight panels the holes or recesses resulting from the foam tube interiors and interstices between the foam tubes are filled with gypsum, cement or other material, and two or more of such panels, in turn, are welded together in mutually offset relationship, excellent sound-absorbent panels are obtained, because the materials contained in the holes or recesses are quasi suspended in the "foam skeleton" of the panels, and the sonic energy is converted to mechanical oscillations of the gypsum or cement plugs.

The super-lightweight panels of the invention are further explained by the additional Figs. 47 and 48, without being thereby limited. In said additional figures the reference numerals have the following meanings:

1 foam tube
2 holes resulting from the foam tube interiors
3 holes resulting from the interstices between the welded foam tubes

Fig. 47 is a plan view of a super-lightweight panel with holes 2, 3 obtained when a block according to the invention composed of round foam tubes is cut vertically normal to the longitudinal axes of the foam tubes into panels of desired thickness.

Fig. 48 is a plan view of a super-lightweight panel with oval holes 2 and extended holes 3 obtained when a block of round foam tubes according to the invention is cut vertically, but at an angle of about 45° with respect to the longitudinal axes of the foam tubes, into panels of desired thickness.

CLAIMS

1. Synthetic resin foam panels or blocks composed of hollow foam profiles adhered and/or welded to one another.

2. Foam panels or blocks according to claim 1, characterized in that they are composed of foam tubes adhered and/or welded to one another.

3. Foam panels or blocks according to claims 1 and 2, characterized in that said foam tubes are arranged side by side in parallel to form a tube panel, or in parallel side by side and one above the other to form at least two superposed tube panels, said tube panels can be so arranged one above the other that the longitudinal axes of the tubes forming the individual stacked tube panels are disposed one above the other in a vertical plane, or vertically above or below the welding area of the adjacent tube panel(s).

4. Foam panels according to claims 1 to 3, characterised in that they are square or rectangular, and in the latter case the tubes are arranged in parallel to the shorter panel edges or in parallel to the longer panel edges.

5. F am panels according to claims 1 to 4, characterized in that one r both panel edges formed by the open tube ends are sealed with a homogeneous or foamed film or she t strip.

6. Foam panels according to claims 1 to 5, characterized in that along the panel edges f rmed by th open tube ends and/or along the panel edges formed by the tube walls on one side one part of a stepped profile, of a round profile, or of a wedge profile, or a groove or a tongue and on the opposite

side the matching profile is provided which, in case of the round profile, can be the tube wall.

7. Foam panels according to claim 6, characterized in that along the panel edges formed by the tube ends matching stepped round or wedge or groove and tongue profiles are formed by cutting the tube body accordingly.

8. Foam panels according to claims 1 to 7, characterized in that the panel edges formed by the tube ends have the shape of a stepped, round or wedge profile or of a groove or tongue by direct cutting, and that corresponding profile bars are welded or adhered to the panel edges formed by the tube walls.

9. Foam panels according to claims 1 to 8, characterized in that all panel edges are provided with stepped, round or wedge profiles or groove or tongue profiles by accordingly profiled bars welded or adhered thereto.

10. Foam panels according to claims 1 to 9, characterized in that in one of the panel edges formed by the tube wall of the tube panel a circular arc or segment-shaped portion is cut out along the longitudinal axis thereof, and in the latter case the corresponding opposite panel edge formed by the tube wall is profiled in wedge form so that as matching part it can extend into the tube with the segment-like gap disposed in a second panel, the inner space of the tube cut to wedge shape being preferably filled with foam.

11. Foam panels according to claims 1 to 10, characterized in that both panel edges formed by the tube walls are cut in segment form along their longitudinal axes so that two matching panels can be interlocked, i.e. the carved-out segments are arranged laterally on opposite sides, the carved-out segments being equal to or somewhat smaller than the thickness of the tube wall.

12. Foam panels according to claims 1 to 11, characterized in that they consist of two superposed tube panels and in the upper tube panel one tube projects entirely or partially along the entire tube length on the right-hand side, and in the lower tube panel one tube corresponding to the right-hand edge projects entirely or partially on the left-hand side so that two such serially arranged panels form a stepped profile.

13. Foam panels according to claims 1 to 6, characterized in that they consist of three superposed tube panels and in the central tube panel one tube projects entirely or partially along the left-hand edge, and in the lower and the upper tube panels one tube each projects entirely or partially corresponding to the tube projecting along the left-hand edge.

14. Foam panels or blocks according to claims 1 to 13, characterized in that cylindrical homogeneous or foamed plugs are introduced into th tube ends which may be pr vided with a profile, said foam plugs may extend out of the tube ends so that they may simultaneously serve as plug connection with the next panel, said plugs then being pref rably made more rigid than the foam tube.

15. Foam panels according to claims 1 to 14, characterized in that the plugs of the plug connection are adhered to the interior walls of the tubes.

16. Foam panels according to claims 1 to 15, characterized in that on one or both side faces they are covered with a rigid or elastic homogen ous or foamed film or sheet, or that on one or on both side faces they have a rigid or elastic, homogeneous or foamed cover layer produced in situ on the side face(s).

17. Foam panels according to claims 1 to 16, characterized in that between at least two tube panels there is a rigid or elastic homogeneous or foamed interlayer.

18. Foam panels according to claims 1 to 17, characterized in that they have spacers on one or both panel faces.

19. Foam panels according to claim 18, characterized in that the spacers are formed by foam tubes having a larger diameter than those of the standard tubes forming the tube panel and replacing a standard tube at spaced intervals, and projecting beyond the panel surface either in onlu one or in both directions.

20. Foam panels according to claim 19, characterized in that the spacers are formed by tubes having a diameter larger than that of the tubes forming the corresponding tube panels, and the tube wall areas projecting beyond the panel plane are pressed down or cut out at spaced intervals.

21. Foam panels according to claim 18, characterized in that the spacers are formed by thin elastic round cords, foam tubules, or optionally wire-reinforced elastic foam rods.

22. Foam panels according to claim 18, characterized in that the spacers are simultaneously provided by the profile bars welded to the various panel edges to form the profiles.

23. Foam panels according to claims 1 to 22, characterized in that the foam tubes forming the foam panels or blocks consist of polyethylene, preferably of low-density polyethylene, and the interlayers — if any — consist of polyurethane or polystyrene.

24. Foam panels or blocks according to claims 1 to 23, characterized in that the inner cavities of the foam tubes are filled with different foams, with foam pellets or chips, or are filled with set materials such as gypsum or cement, or that accordingly dimensioned rods of rigid, elastic, foamed or non-foamed materials are inserted in the inner cavities.

25. Foam panels according to claims 1 to 24, characterized in that not only the inner cavities of the foam tubes welded together are filled according to claim 24, but that in this way also the voids are filled which remain free when at least two tube panels are welded together.

26. Foam panels or blocks according to claims 1 and 25, characterized in that they comprise at least two superposed tube panels at least one of which is so arranged that the tubes of the tube panel extend normal to the tubes of the other tube panel.

27. A process for producing foam panels or blocks according to claims 1 to 26 by continuous sheet welding of rigid or elastic homogeneous or foamed thermoplastic synthetic resin hollow profiles, especially foam tubes, in which the synthetic resin surfaces to be welded together are first melted and then pressed together, characterized in that the

synthetic resin surfaces to be heated up to melting temperature are guided over a spacer means at a distance around the lectrically heated heat conductor serving as heat source in such a way that the synthetic resic surfaces to be welded together and the spacer means form a heating channel surrounding the heat source, and said heating channel can optionally be closed at its forward and rearward ends.

28. Process according to claim 27, characterized in that the foam tubes to be welded together consist of a polyolefin, preferably a polyethylene, especially of a non-cross-linked polyethylene.

29. Process according to claims 27 and 28, characterized in that the foam tubes to be welded together consist of an elastic foamed low-density polyethylene, preferably one having a volume weight of less than 50 kg/m^3.

30. Welding apparatus for carrying out the process according to claims 27 to 29, characterized in that it comprises at least one electrically heatable heat source, a spacer means arranged in front of said heat source(s) and a means for pressing the superficially molten surfaces together.

31. Welding apparatus according to claim 30, characterized in that the electrically heatable heat source is a heat conductor in the form of a wire or a metal strip preferably made of a chromium-nickel alloy, a chromium-nickel-aluminum alloy, or of an iron-chromium-nickel alloy.

32. Welding apparatus according to claims 30 and 31, characterized in that the electrically heatable wires or metal strips are always held in taut condition, also when heated, by means of a tensioning device.

33. Welding apparatus according to claims 30 to 32, characterized in that the spacer means has the shape of a wedge-like heat shield.

34. Welding apparatus according to claim 33, characterized in that the wedge-shaped heat shield comprises in longitudinal direction one or more passageways provided for the passage of coolant medium, preferably in the form of one or more suitable bores.

35. Welding apparatus according to claims 30 to 32, characterized in that the spacer means is formed by a pair of rolls, said rolls being preferably supported by ball bearings and having an elastic synthetic resin jacket.

36. Welding apparatus according to claim 35, characterized in that the rolls are hollow rolls through which coolant medium flows.

37. The use of the foam panels according to claims 1 to 26 for thermal insulation, especially for insertion into the space in external building walls consisting of the supporting wall proper and the facing wall spaced therefrom, for installation between the rafters as roof insulation panels, as cast plaster floor insulating panels, and as thermally insulating drainage panels provided underneath foundations and as xternal insulation for underground brickwork.

38. Th use of the foam blocks acc rding to claims 1 to 3 for the production of super-lightweight panels, characterized in that from the foam blocks panels are cut off vertically, i.e. normal to the longitudinal axes of the tubes, or at any desired other angle with respect to the longitudinal axes of the tubes, and the thus btained panels ar pr vided with facing layers, or are again welded together in mutually offset arrangement, or are welded together in alternating sequence with non-perforated foam panels to form thick super-lightweight panels, or the holes in said super-lightweight panels are filled with gypsum or cement or other material, and such panels are again welded together in mutually offset arrangement, or are bonded in alternating sequence to non-perforated foam panels to form a thick sound-absorbent panel which may optionally be provided with facing layers, e.g. of wood (chip board) or sheet metal.

39. A synthetic foam panel or block substantially as hereinbefore described with reference to any one of Figs. 1 to 46 of the accompanying drawings.

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